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THE AGRICULTURAL DEPRESSION.

THE depression in world trade has continued unabated during the past year and hardly a single industry can be said to have escaped entirely from its effects. Agricultural industries in the tropics have suffered their full share of the general fall in the price level. Many planters are at present being confronted with severe difficulties and since their plight is due to causes over which they have practically no control, they are almost powerless to deal with the situation. The causes of the present crisis are very difficult to explain and the intricacies and magnitude of the problem are such that they have baffled many brains. There is no doubt, however, that the world is undergoing profound changes, the depths of which have not yet been fathomed. The war helped considerably to accelerate these changes by dislocating the world's pre-war economic stability and by destroying the economic interdependence of nations. "There is neither any material shortage in the resources of Nature, nor any inadequacy in man's power to exploit them. The problem, in one way or another, appears to be a form of maladjustment. Economic revival and progress have been hampered by the free flow of labour, capital and goods, largely resulting from the ill considered action of many nations". The growth of economic nationalisation, urging countries to policies of self-sufficiency, rather than to the development of international trade; the slow revival of confidence amongst nations with the return of peace; and a collapse in the monetary system; have all been accessory facts to the present distress.

To particularise. With regard to agriculture the depression* is believed to be due to "the disproportionately low level of prices of agricultural products, greatly aggravated by their instability, which has been steadily increased since 1927. This disproportion means, on the one hand, that the proceeds of the farmers' output buy less and less of the goods they consume, and on the other, that the margin between cost of production and selling price is steadily reduced. None of the elements in cost except fertilisers and fodders, has fallen as fast as selling prices: wages have been fairly steady, fiscal burdens have increased, and interest, already very much higher than before the war, grows more burdensome as the purchasing power of money increases."

* *The Economist*, Vol. CXIII, No. 4589.

The causes of this state of affairs are to be found on the side both of consumption and of production. Many agricultural commodities supply a demand which increases little more rapidly than the population. The expansion of the consumption of foodstuffs is further restricted by the invention of methods of preservation and of more complete utilisation. Both foods and agricultural materials have been affected by changes in taste. On the other hand, some changes in consumption, consequent in part upon dietetic propaganda, and in part upon improvement in standards of living, redound to the advantages of producers of particular staples. The general industrial depression, however, by reducing purchasing power, has largely counterbalanced the effects of this tendency. On the production side, one of the main influences making for over expansion has been the great strides made in agricultural technique, which have brought about an increasing use of machinery and a great improvement in the use of fertilisers, in the process of plant selection, and in cultivation methods generally.

In view of these advances in methods of agricultural production and of the fact that population is not likely to rise to any considerable extent, Professor Cannan* tells us that "we no longer look forward to a future in which an increasing population will be forced by the operation of the law of diminishing returns to devote a larger and ever larger proportion of its whole labour force to the production of food". In effect, "under the combined influence of the narrow capacity of the individual human stomach and the stationary number of stomachs, not only a smaller and ever smaller proportion, but also a smaller and smaller absolute number of workers will be able to raise food for the whole." Thus, as we have repeatedly stated in the past there is greater need at present for a policy aiming at the consolidation of existing areas of production than at the development and expansion, for agricultural purposes, of new tracts of territory. It follows, also, that there are distinct dangers in any political devices calculated to keep excessive agricultural producing areas in existence since they will merely lead to a further depreciation in the value of agricultural products.

The arguments first outlined can be applied to the present state of agriculture in the tropics, but the main issues, which have also been discussed, and which govern the whole crisis must not be overlooked as they, also, are largely responsible for our troubles. The future remains obscure. In the past, nations have attempted to grapple with their own economic difficulties singlehanded and in doing so have almost disregarded those of their neighbours. With the present crisis, however, the dangers of following such selfish policies are gradually being realised. Recovery should, therefore, in some measure depend on the quickness with which nations will realise the need of re-adapting themselves to changing world conditions, and on the degree of co-operation and understanding with which, it is hoped, problems of world commerce and finance will be approached.

* Population and Production. *Nature*, Vol. CXXVIII, No. 3233.

LEAF FALL IN THE TROPICS.

Mr. R. E. Holtum has recently put on record (*The Gardens' Bulletin*, Straits Settlements, Vol. V, Nos. 7 and 8, June, 1931), the behaviour as regards leaf-fall and the flowering of a number of trees in Singapore, thus rendering comparison possible with the behaviour of similar trees in the more seasonal tropical climates of Java and Ceylon, on which Coster and Wright have previously made similar observations. The climate of Singapore is very uniform throughout the year, but there is usually a definite change to drier conditions after the north-east monsoon in February, and also some tendency for July and August to be comparatively dry. It is, therefore, interesting to note that trees of a number of deciduous species change their leaves annually about February, whilst a few species change their leaves in August and four species were observed to change their leaves twice a year, usually in February and August. A number of other species change their leaves at approximately constant intervals, which, however, have no reference to the faint seasonal cycle, so that, though the intervals are equal in time, they have no reference to the annual cycle and fall upon different months in successive years. These trees, especially, show variation from tree to tree within the same species, and Holtum's observations, since 1927, have been based upon weekly observations upon the same individuals.—(*Nature*, Vol. 128, No. 3236.)

DOMINICA FRUIT FLIES.

Mr. F. W. Urich recently paid a visit to two localities in Dominica with a view to establishing the existence and status of certain fruit flies which were observed, after a long drought at the end of last year, to attack oranges and grapefruit.

Previous records had shown that in 1909 *Anastrepha acidusa* Wied (1), determined by Coquillet (2) of the United States National Museum, Washington, was found to affect guavas. At the time of Mr. Urich's visit no guavas were fruiting and only a few ripe oranges and grapefruit were found on the upper part of the Imperial Road. These were unaffected by fruit flies. Mr. Urich discovered, however, that the West Indian Fruit Fly, *Anastrepha fraterculus*, was breeding extensively in Pomme Rose, *Eugenia jambos*, which, as it grows near orange fields, may be a host plant carrier of this insect. *A. fraterculus* has not yet been established, however, as having affected citrus. Another likely host plant is "Poisdoux", *Inga* sp., which is grown for shade in Dominica and the fruit of which is attacked by *A. fraterculus* in Trinidad. Neither this tree nor "Hog Plum", *Spondias lutea*, which is also a host plant for *A. fraterculus* were fruiting at the time of Mr. Urich's visit. In the vicinity of Roseau, mangoes were discovered heavily infested with *A. fraterculus*, the common species suffering far more than "Julies".

(1) *Anastrepha acidusa*, Wied, quoted by Wolcott as a synonym of *Anastrepha fraterculus* in *Insecta Portoricensis*.

(2) *Agricultural News*, Vol. VIII, p. 93.

BANANA DISEASES.

4.—Notes on "Black-tip" disease in Trinidad; Helminthosporium torulosum (Syd.) comb. nov. Ashby.

By C. W. Wardlaw.

Literature.

The fungus responsible for this disease was first described by Ashby (2) as the cause of a leaf-spot of the Gros Michel banana in Jamaica. He also noted that young fruit may be badly spotted but no rotting ensues. The organism was described under the name of *Cercospora musarum* Ashby. Its importance as a parasite on fruit was first noted by Ogilvie (6, 7, 8, 9) who found that it was responsible for the disease described as "Black-tip" on the Dwarf, Canary or Cavendish variety (*Musa Cavendishii*) in Bermuda. More recently this disease has been observed on the Cavendish (Governor) and Lacatan varieties in Trinidad (10), while the fungus has also been isolated from fruit-spots and wound blemishes on the Gros Michel (10), and from leaf-spots on the Cavendish. It has also been recorded from Peru (1). Until recently this organism had been regarded as purely occidental, but recently Mitra (4) has observed bananas to be attacked by it in the Central Provinces, India.

The fungus has been re-named *Helminthosporium torulosum* (Syd.) Ashby comb. nov. (3). (Synonyms :—*Brachysporium torulosum* Sydow., in Hedwigia XLIX, p. 83, 1909: *Cercospora musarum* Ashby (2)).

Symptoms.

In Bermuda under certain conditions a black discolouration becomes apparent just below the flower and progresses down the fruit so that in about three weeks two inches may have become affected. The diseased areas, bordered by a narrow grey or light yellow margin, are frequently irregular in outline, one side of the fruit being more affected than another. At a relatively late stage, when the discolouration has progressed some distance, pale brown mycelial wefts of *H. torulosum* may be observed on the surface, extending to within three mm. of the margin of the lesion. Later these hyphae tend to be obscured by overgrowth of other fungi. Ogilvie(9) observed that the whole fruit is seldom affected and that ripening appears to inhibit the further development of the disease.

In older infections the blackened areas frequently become disrupted apparently as the result of desiccation and insect activity. The extent of the damage is thus increased. (Figs. 7, 8.)

While the fruit is rendered unsightly by the shrinking and blackening of the tip, the amount of internal decay produced is negligible, the fungus being mainly active on the green skin.

Occurrence in Trinidad.

In Bermuda the disease has been described as somewhat serious and Ogilvie's illustration shows part of a bunch in which the majority of the finger-tips are affected, while some of the infections are stated to extend over a length of two inches. In Trinidad the writer has only found isolated specimens of the disease, but in three different areas, namely, on the Lacatan variety on the College grounds, and on the Cavendish variety (Trinidad Governor) at River Estate and in the Arena Forest Reserve. Further, the infections were never observed to extend over more than three-quarters of an inch and more than three diseased fingers were seldom found in a bunch. Again, while positive results were obtained from inoculation experiments, the disease effects were never produced so rapidly or so extensively as those in Bermuda.

Influence of External Conditions.

Ogilvie states that the disease is most noticeable on both fruits and leaves during the summer months in Bermuda (late June, July, August and September), when the mean maximum temperature is above 75°F. By the beginning of October young fruits show comparatively little infection. He thus calls attention to temperature as an accessory external factor. In Trinidad (where comparatively equable temperatures obtain throughout the year) infections have been found at the beginning and during the dry season, but the progress of the disease was invariably very slow, while inoculation experiments carried out during this season consistently yielded negative results. Similar experiments conducted during the rainy season yielded disease effects comparable to those normally observed.

Detailed Observations.

The extent of internal rotting produced is insignificant. On cutting open a diseased fruit the affected tissue is found to be black in colour and of a dry crumbling consistency. In the specimens examined the flesh was not found to be affected to any marked extent except in the vicinity of the extreme tip (Fig. 1). No extensive internal breakdown has been observed.

In the earlier stages of infection the hyphae can readily be seen in both skin and flesh. In the latter they traverse the tissue by cell to cell penetration, the fungus evidently being able to dissolve its way easily through the cell walls (Fig. 2). Sometimes the hyphae may be observed in the inter-cellular air spaces and occasionally in the middle lamellae, but direct progress from cell to cell is by far the most common. Except in the later stages of infection the tissue of the flesh does not become deeply discoloured.

In the initial stages the skin tissues though freely penetrated by hyphae (Fig. 3) remain light coloured, but as the disease reaches a more advanced stage the invaded cells acquire a dark brown colour on account of the deposition of gummy and tannic substances within. Similar

depositions are found in the inter-cellular spaces and on the walls (Fig. 4). As a result the hyphae become obscured, and may be difficult to distinguish. That they are still viable, however, is indicated by the formation of numerous conidiophores over the surface of the epidermis.

As a rule the conidiophores arise singly or in small clusters from the epidermis. As mentioned above this takes place at a relatively late stage in the infection when the tissue is dark coloured, shrunken and disrupted. Thus, while the conidiophores themselves stand out conspicuously it is only with difficulty that the hyphae from which they arise can be observed in the epidermal and sub-epidermal cells (Figs. 5, 6). The conidiophores which develop are comparable to those obtained on synthetic culture media.

While marked shrinkage was evident in the older infected regions, the general folding and corrugation of tissues observed in *Stachylidium* infections (11), was present only to a small extent.

The external appearance of Black-tip disease indicates that the infection originates in the perianth or style and that the passage of hyphae into the fruit takes place as a result of delayed or incomplete formation of the corky layer which normally seals up the distal end on the decay of the old floral parts. As a rule the latter process takes place quickly and the corky layer begins to be apparent as soon as withering is in progress. In longitudinal sections through diseased tips it was found that hyphae were present in great abundance at the base of the decayed style and perianth and from there they could be traced downwards into the tissues of the skin and flesh. It was noted that while a barrier of cork cambium had been formed across the distal end, suberisation of the walls must have been delayed since the component cells had sometimes been penetrated by hyphae. At other points the corky layer appeared to be undeveloped or incomplete. As a rule the development of this layer was more advanced in the peripheral regions and there hyphae were less in evidence or absent.

The Fungus.

When first isolated and described by Ashby (2) the fungus was regarded as a species of *Cercospora* and was tentatively named *C. musarum*. Mason (3), however, points out that this organism had previously been recorded as *Brachysporium torulosum* Syd., and has advanced reasons for removing this species to the genus *Helminthosporium*.

By way of amplifying our knowledge of *H. torulosum*, the fungus was grown on a number of different media of the following compositions :—

			Medium.	Sucrose in gms. per litre.
Potassium phosphate	.. 1.25 gms.		No. 1	5
Magnesium sulphate	.. 0.75 do.	+	No. 2	10
Asparagin	.. 2.00 do.		No. 3	25
Agar	..20.00 do.		No. 4	50
Water	.. 1000 ccs.		No. 5	100

The growth characters of the colonies as a whole will be described in the next section.

On medium No. 1 (0.5 per cent. sucrose) conidia were produced in great abundance. The conidiophores, according to age, may be simple or considerably developed. They arise from colourless procumbent hyphae (Figs. 9, 10) and increase in diameter, finally terminating in a swollen head (10-15μ diameter) on which a single conidium is borne. The conidiophores acquire a brownish colour from an early stage (Fig. 10). The formation of the conidium is initiated by a process of budding at the tip of the conidiophore (Fig 19). The newly formed cell quickly swells out (Fig. 20), then elongates (Fig. 21), and finally a transverse septum appears, usually towards the distal end (Fig. 22). Sometimes a transverse septum is present from a very early stage (Fig. 23). The conidia are at first hyaline and highly vacuolated. As they increase in length additional transverse septa appear till as many as 11 or 12 may be present (Fig. 15). Ashby has described them as smoky olive in colour, pear-shaped, widest above the base and narrowing thence to a blunt point. This is most characteristically seen in the shorter stumpy forms. At the base of each is a little disk where attachment was made to the swollen head of the conidiophore. Ashby's measurements for the longer conidia are 50-60μ (—90μ) $\times$ 16-17μ and for the shorter forms 30-40$\mu \times$ 16—17μ. On the dilute sucrose medium (No. 1) the largest conidia measured 160$\mu \times 20\mu$, intermediate ones 85$\mu \times 18\mu$ and the smaller ones 50-60$\mu \times$ 10-14μ (Fig. 15). On this medium the walls, though relatively thick (Fig. 33), were not highly chitinised as on some other media. The individual cells were vacuolated with a somewhat granular peripheral cytoplasm.

Only one conidium, readily detached at maturity, is formed on each inflated head. While the conidium is still attached or after it has become dislodged the conidiophore continues to grow. This may take place in various ways. In the simplest cases growth is continued by the pushing out of a branch from the swollen conidiophore head, usually at some lateral point on the surface. The branch is at first hyaline with a conspicuously vacuolated protoplasm, (Figs. 25, 26, 36). Later it elongates further, acquires the characteristic brown colour, enlarges and bears a conidium as before (Fig. 14). This process may be repeated several times so that in old cultures conidiophores, much elbowed (Fig. 13), and of considerable length, are the rule (Fig. 12). Occasionally two branches may pass off from the terminal head (Fig. 11).

The elongation of the conidiophore may also be continued by a second means, namely, by the upward growth of the cell immediately below the head. According to Mason (3) "The first impression that one gets is that this secondary growth is inside the conidiophore and grows right through the apical head, as Miyabe figures for *Macrosporium parasiticum* Thum. (5). At

BANANA DISEASES.

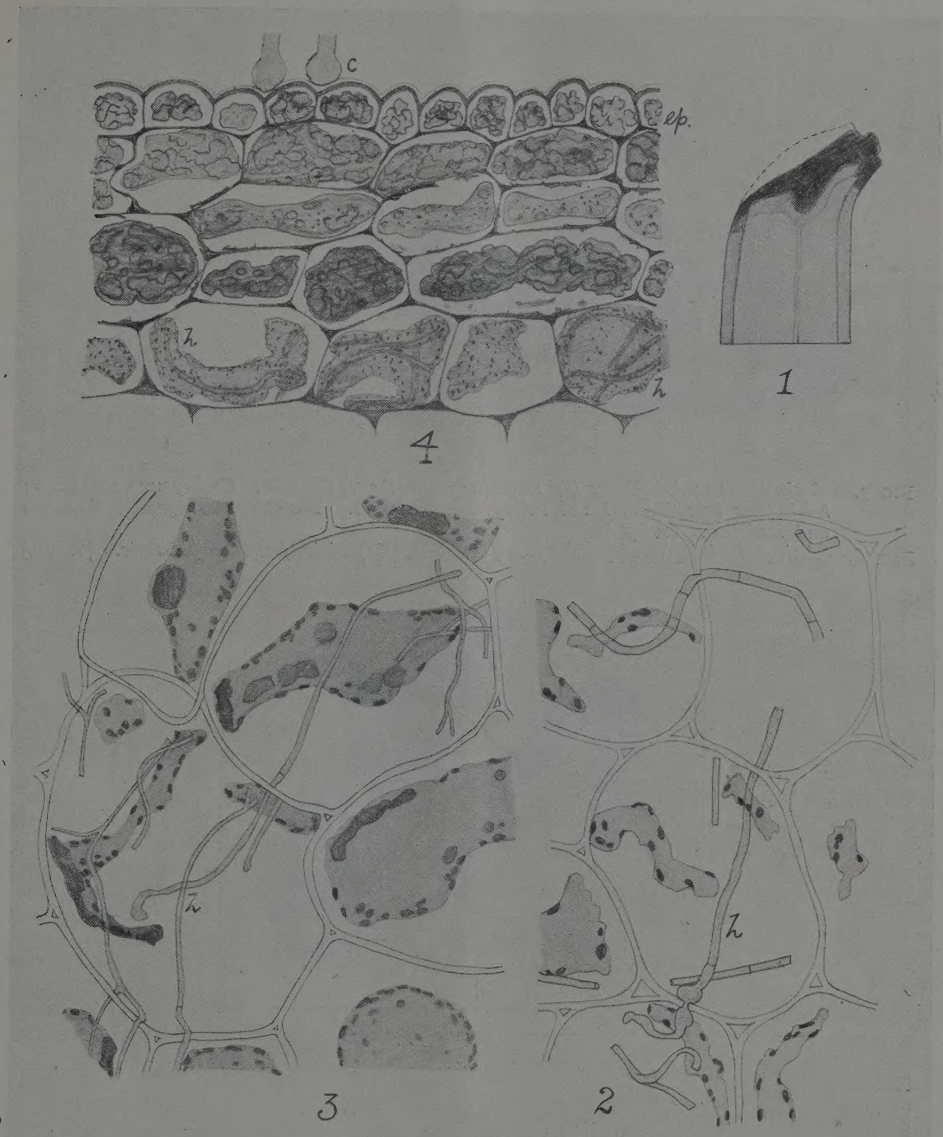


FIG. 1.—*Longitudinal section (diagrammatic) through a Black-tip infection showing the extent of rotting.* (×3/5).
FIG. 2.—*Hyphae in the tissue of the flesh.* (×780.)
FIG. 3.—*Hyphae in the inner tissue of the skin—an early stage.* (×780.)
FIG. 4.—*Appearance of the skin tissues—a later stage showing the dark, gummy cell contents; ep.—epidermis; c—conidiophore; h—hyphae.* (×450.)

BANANA DISEASES.

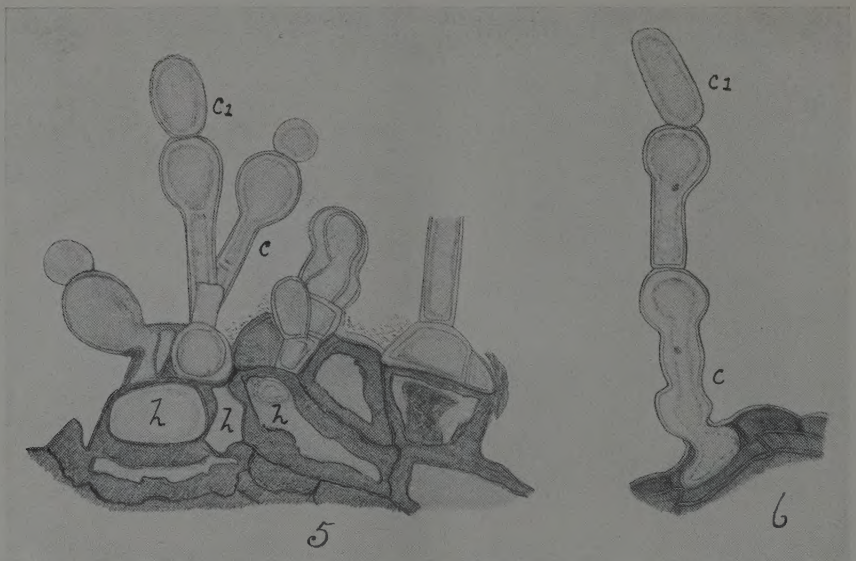


FIG 5.—*A cluster of conidiophores (c) emerging from the epidermis; C1.—young conidium; h—hyphae in epidermal and sub-epidermal tissues. The latter are greatly shrunken and modified.* (×870.)

FIG. 6.—*A single conidiophore (c) with a young conidium (C1) arising from the epidermis.* (×870.)

Fig. 7.

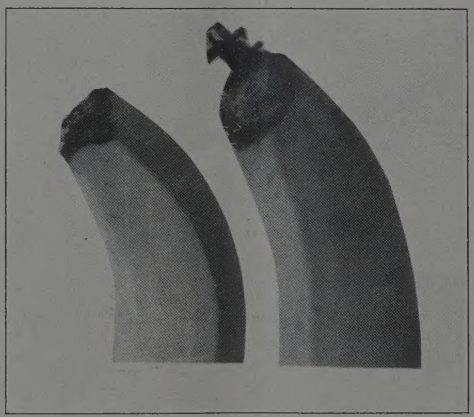
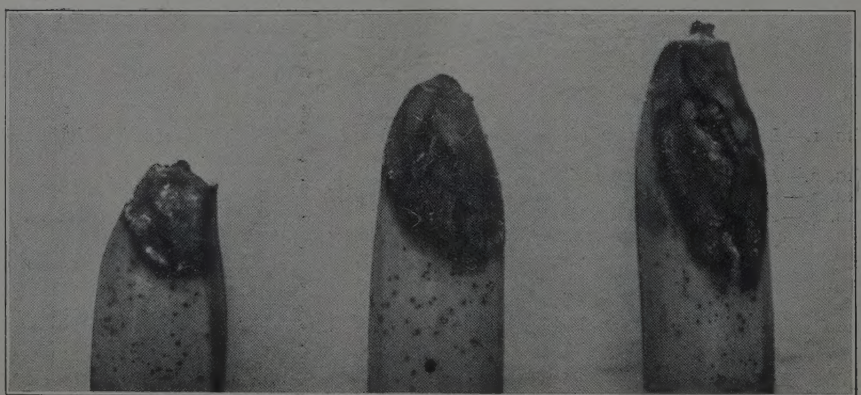


Fig. 8.



FIGS. 7, 8.—*Typical examples of Black-tip disease on the Cavendish and Lacatan varieties respectively.*

other times it appears to be outside the conidiophore but closely adpressed to the apical head, as Ashby has figured and described it." The writer has seen many specimens illustrating the first description but not the second. The following developmental stages were noted (Figs. 28-31). In some of the conidiophores it was observed that the penultimate cell proceeded to grow, as indicated in Fig. 28, into the cavity of the swollen terminal cell, in which, as a rule, the normal protoplasmic contents appeared to be degenerate or absent. As this growth continued the hypha could be unmistakably observed inside the terminal cell (Fig. 29). By further elongation the hypha passed out through the wall of the terminal cell, generally at the point where it was weakened by the detachment of the conidium (Fig. 30). At the same time it was frequently noted that that portion of the hypha within the terminal cell commenced to swell out so as to occupy all or much of the available space (Figs. 30, 31). Finally the hypha developed into a typical conidiophore (Figs. 31, 35). Where the secondary hypha passed out from the terminal cell in a more lateral or tangential direction, the terminal cell appeared to be thrust to one side and had the empty vestigial appearance suggested in Ashby's illustrations.

A considerable body of evidence obtained from examinations of the fungus on various synthetic media indicates that not only the terminal cell of the conidiophore, but also cells of the general mycelium and of the conidia, may frequently suffer from some protoplasmic derangement so as to incur loss of turgor. The adjacent cells then proceed to grow into the less turgid cells with the results shown in Figs. 28-31. On this same medium (No. 1) three or four adjacent cells of a conidiophore have been observed successively undergoing this type of renewed intracellular growth. Further, in the case of conidia still attached, it was sometimes found that germination had taken place and that the germ tube had penetrated downwards into the terminal cell of the conidiophore. Fig. 32 shows a conidium in which the germ tube has grown out from the second end cell, passed through the basal cell and thence into the terminal cell of the conidiophore. A still more frequent instance of this phenomenon consisted in the terminal cell or cells of the conidium becoming deranged so that, as indicated in Fig. 24, the cavity was finally occupied by a hypha arising from a cell lower down.

The foregoing account incorporates the principal observation made on the behaviour of the fungus on the dilute sucrose medium No. 1. At the higher sucrose concentrations the fungus showed a noticeable response in various ways. The mycelium became more densely granular and oily, the normal submerged hyphae were frequently inflated and contained oily protoplasmic contents (Fig. 17), the general pigmentation of the mycelium was accentuated, and the conidia had walls which were greatly thickened and chitinised (Figs. 16, 34). While the shorter conical conidia predominated long slender conidia and very short ovoid ones were also observed (Fig. 16). The behaviour of the conidiophores was as before. Samples taken from the dense weft of dark mycelium close to the medium contained stout dark hyphae distally swollen as described by Ashby. Their structure was suggestive of modified conidiophores. Not infrequently on this medium (No. 5) the mature conidium, while still attached, had continued growth and developed into a short conidiophore which in turn bore a terminal conidium (Fig 18); other conidia were also observed which had germinated and developed into relatively elbowed conidiophores.

On Richards' solution agar (which contains five per cent. sucrose and a high mineral content) the mycelium was similar to that obtained from Medium No. 5 above. The conidia which were produced in abundance and measured 30—130μ $\times$12—16μ, had walls intermediate in character between those described from the sucrose media Nos. 1 and 5.

On concentrated media of the type described above, hyphae of the procumbent vegetative mycelium were sometimes joined together by conjugation tubes (Fig. 27).

Using the same asparagin and mineral content as in the media described above but with starch (2.5 per cent.) as the source of carbohydrate, sporulation was abundant and uniformly large conidia measuring 60—120μ $\times$16—18μ were the rule. On a corresponding maltose medium the conidia measured 45—80μ $\times$12—18μ.

The extent of sporulation and size of conidia also varied according to the way in which nitrogen was supplied. On a standard medium (2.5 per cent. sucrose plus minerals as before) with .25 per cent. potassium nitrate added the conidia were normal (30-100μ $\times$12—16μ) but produced in small numbers. On a corresponding peptone medium sporulation was very abundant, and the conidia (which measured 30—100μ $\times$12—18μ) were frequently observed to grow out into conidiophores with one, two or more inflated fertile cells. On a medium supplied with ammonium chloride as the source of nitrogen, conidia were absent or exceedingly scanty. On a urea medium sporulation was normal.

At high asparagin concentrations (*e.g.* 2 percent.) conidiophores were formed but sporulation was very scanty and in both conidiophores and conidia a number of abnormal features were present. With .5 per cent. asparagin sporulation was more abundant and long conidia measuring 120μ $\times$16μ were observed. On a .2 per cent. asparagin medium the characteristic abundant sporulation already described was obtained. On the standard medium in which asparagin had been left out, sporulation was still relatively abundant and thick walled conidia measuring up to 130μ $\times$16μ were noted.

Growth of Fungus on Different Media.

On the sucrose media Nos. 1-5 described above, the fungus first forms an abundant white aerial mycelium which becomes pale-grey and finally a dark fuscous grey. The rate of growth, as indicated by the following Table and the amount of pigmentation increase with the concentration of sucrose.

Medium.	Colony Diameter in cms.	
	4 days.	6 days.
No. 1	2.6	4.6
No. 2	2.8	5.0
No. 3	3.2	5.1
No. 4	3.5	5.5
No. 5	3.9	6.0

The growth of the fungus was tested on a considerable number of different sources of carbon. The following growth measurements were obtained on glucose, sucrose, maltose, starch and cellulose at a concentration of 2.5 per cent.

Source of Carbon.	Colony Diameter in cms.	
	5 days.	7 days.
Glucose	4.7	7.0
Cane Sugar	3.8	6.3
Maltose	4.7	7.5
Starch	4.0	5.7
Cellulose	2.4	3.7
No Carbon	2.4	3.6

The culture on the medium containing no carbon (other than that provided by the agar) was staled, submerged and practically colourless; it had some brown-coloured hyphae and conidiophores but no conidia after 14 days. The others had abundant aerial mycelium of a whitish grey colour, and sporulation was normal. The growth on glucose, maltose, and starch, as compared with that on cane sugar, suggests points of interest in the metabolism of this organism worthy of further investigation. On a medium in which the source of carbon was cellulose, the fungus made the same poor growth as on a carbon-free medium.

The fungus also showed variation in growth rate according to the source of nitrogen. Thus three organic sources of nitrogen, asparagin, albumen and peptone yielded higher growth rates than two inorganic sources, *e.g.* nitrate and an ammonium salt. With the exception of a medium in which nitrogen was supplied as ammonium chloride all the colonies were closely comparable in appearance and after 20 days consisted of the typical abundant, dark, aerial mycelium.

Summary.

1. In this paper short notes on a plantation fruit disease of the banana, known as Black-tip disease, are submitted. The fungus, *Helminthosporium torulosum* (Syd.) comb. nov. Ashby, has been recorded from Jamaica, Bermuda, Trinidad, Brazil, Peru and the Central Provinces, India. It is chiefly important as the cause of a fruit rot of the Cavendish variety in plantations in Bermuda and of a leaf-spot of the Gros Michel in Jamaica. In Trinidad it has been isolated from a Black-tip disease of the Cavendish and Lacatan varieties, from fruit-spots and wound blemishes on the Gros Michel, and from leaf-spots on the Cavendish.

2. The symptoms exhibited by Trinidad specimens of fruit disease are similar to those described in Bermuda, but they develop less rapidly and are less extensive.

3. In Bermuda temperature appears to be an accessory factor since the disease characteristically appears during the warm summer months. In Trinidad this factor may be ruled out. In inoculation experiments negative results were obtained during the dry season and positive results during the wet season.

4. An account is given of the behaviour of the fungus in the tissues of its host. The skin tissues are markedly affected but the flesh is only attacked to a slight extent.

5. The development of the fungus on several synthetic culture media is described.

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FIELD EXPERIMENTS.

A Note on Residual Variance in Field Experiments.

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THERE appeared in this Journal a paper by Maskell (1) giving a simple exposition of the principles underlying modern field experimental lay-out, described in Dr. Fisher's (2) book. The purpose of this paper is to give examples which have been found useful in making clear the basic conception of the analysis of variance to students desiring to go a stage further back in the mathematics.

Variance.

When the plot yields from an experiment are examined it is found that the variation conforms to no readily observable plan. Two major factors are acting—the different fertility levels of the plots and the differential effects of the treatments. Statistical analysis aims at assessing the total variation and then apportioning it between the various factors.

In the following example, a 4 × 4 Latin Square is taken, in which the yields are the first 16 natural numbers.

1	2	3	4	10
5	6	7	8	26
9	10	11	12	42
13	14	15	16	58
28	32	36	40	136
				8.5

A	B	C	D
B	A	D	C
C	D	A	B
D	C	B	A

The reason for the Latin Square lay-out is to enable an exact allocation of the variation due to the different fertility levels in the respective rows and columns; and as each row, and each column, contains the same *total* application of treatment, it is held legitimate to assess this variation from the row, and the column, means. The general mean is 8.5. The total variation, measured by the total sum square difference, is the sum of the 16 terms $(1-8.5)^2+(2-8.5)^2+(3-8.5)^2+\ldots+(16-8.5)^2$ and is found to be 340. Without going into the method, which is dealt with below, it may be noted here that the sum square difference due to columns is 20, and that due to rows, 320. For treatments it is nil.

Sum Square Differences	due to :—	Rows	320
		Columns	20
		Treatments	0
		Error	0
		Total	340

This is expected, as the yields are arranged in two perfect fertility gradients at right angles, and no other variation is introduced. The variation due to these fertility gradients is taken out in the row and column differences respectively. In an actual experiment, variation due to treatment is also found, and a residual variation which is the basis of the error calculation, and is got from the difference between the total, and the sum of the row, column, and treatment, sum square differences. This residual variation is due to the different fertility levels of the plots, which do not conform to a regular linear fertility gradient either down or across.

Residual Variance.

Although it is usual to determine the error or residual variance, by difference, it may be calculated directly. For this purpose a new 4 × 4 Latin Square has been taken, in which there are differences due to treatment and irregular (non-linear) fertility gradients.

Yields.

18	24	20	26	88	22
34	60	30	36	160	40
22	24	46	28	120	30
38	36	40	62	176	44
112	144	136	152	544	136
28	36	34	38	136	34

Treatments.

A	B	C	D
C	D	A	B
D	C	B	A
B	A	D	C

Treatment Means.

	A	B	C	D
	18	24	20	26
	30	36	34	60
	28	46	24	22
	36	38	62	40
Total :	112	144	140	148
Mean :	28	36	35	37

The ordinary analysis may be carried out in various ways, depending on the method of partitioning the variance.

Of the 15 degrees of freedom, we have

Rows	.. ..	.. 3
Columns	.. ..	.. 3
Interaction between Rows and Columns	3 × 3 =	9
		15

The Interaction variance is split up further into that due to treatment, and residual.

Rows	.. ..	.. 3
Columns	.. ..	.. 3
Treatments	3	
Residual	6	 9
		15

The within treatment variance contains the row and column and residual variances with 12 degrees of freedom. Within each treatment there are three degrees of freedom, and so for the four treatments, 4 × 3 degrees. This partitioning is therefore :—

Between treatments ..	.. 3
Within treatments 4 × 3 =	12
	15

Maskell's Method.

Using the following notation,

x = any one reading. | x_t = any treatment mean.
$\bar{x}$ = general mean. | x_c = any column mean.
S = grand total. | x_r = any row mean.

The identities for the various parts of the variation are :—

Variation Factor.	Sum Square Difference.	Degrees of Freedom.
1. Between Treatments	$4 \times \sum_{1}^{4}\left[x_t - \bar{x}\right]^2 = 4\sum_{1}^{4} x_t^2 - S.\bar{x}$	$4 - 1 = 3$
2. Within Treatments ..	$\sum_{1}^{16}\left[x - x_t\right]^2 = \sum_{1}^{16} x^2 - 4\sum_{1}^{4} x_t^2$ (the relative x_t is used for each group of four x's	$4(4 - 1) = 12$
3. Rows	$4\sum_{1}^{4}\left[x_r - \bar{x}\right]^2 = 4\sum_{1}^{4} x_r^2 - S.\bar{x}$	$4 - 1 = 3$
4. Columns	$4\sum_{1}^{4}\left[x_c - \bar{x}\right]^2 = 4\sum_{1}^{4} x_c^2 - S.\bar{x}$	$4 - 1 = 3$
5. Residual	$2 - (3 + 4)$	$12 - 6 = 6$

1. *Between Treatments.*

$$4 \times \sum_{1}^{4}\left[\text{Treatment mean} - \text{General mean}\right]^2$$

$$= 4\left[(28-34)^2 + (36-34)^2 + (35-34)^2 + (37-34)^2\right]$$

$$= 200$$

2. *Within Treatments.*

$$\sum_{1}^{16}\left[\text{Plot yields} - \text{relative treatment mean}\right]^2$$

A plots $(18-28)^2 + (30-28)^2 + (28-28)^2 + (36-28)^2$
B plots $(24-36)^2 + (36-36)^2 + (46-36)^2 + (38-36)^2$
C plots $(20-35)^2 + (34-35)^2 + (24-35)^2 + (62-35)^2$
D plots $(26-37)^2 + (60-37)^2 + (22-37)^2 + (40-37)^2$
$= 2,376$

3. *Between Rows.*

$$4 \times \sum_{1}^{4}\left[\text{Row mean} - \text{General mean}\right]^2$$

$$= 4 \times \left[(22-34)^2 + (40-34)^2 + (30-34)^2 + (44-34)^2\right]$$

$$= 1,184$$

4. *Between Columns.*

$$4 \times \sum^{4} (\text{Column mean} - \text{General mean})^2$$

$$= 4 \times \{(28-34)^2 + (36-34)^2 + (34-34)^2 + (38-34)^2$$

$$= 224$$

The Table of Analysis of Variance can then be constructed :—

Variation Factor.	Degrees of Freedom.	Sum of Squares.	Variance.
Between treatments ..	3	200	66.6
Within treatments ..	4 × 3 = 12	2,376	198.0
Between Rows ..	3	1,184	394.7
Between Columns ..	3	224	74.7
Residual ..	12−3−3=6	968	161.3

The degrees of freedom are one less than the number of readings concerned. They express the number of readings to which arbitrary values could be assigned. In calculating the sum square differences, deviations have been measured from the mean ; arbitrary values could be assigned to the first $n - 1$ readings, but the last would be fixed, and equal to the difference between the total (which is n times the mean), and the sum of the first $n - 1$ readings. In other words one degree of freedom has been used up in calculating the first moment from the data—the mean. In the "within treatments", differences have been calculated from a mean in each of four cases. For each treatment, there are $(4 - 1)$ degrees of freedom, and so four times this for all the treatments, *i.e.*, 12. The "within treatments" sum squares contain all the variation not due to differences between the treatments, and so include that due to the different fertility levels. That due to the differences between rows and columns has been calculated, and so by difference, the part due to the irregular fertility levels can be found. The 12 degrees of freedom, minus three for rows, and minus three for columns, leaves six for this residual variation. Similarly, the sum square difference assessing this residual variation is got by subtracting that due to rows and columns from the "within treatment" figure.

Short Method (3 and 4).

The work may be simplified in two ways—by working in totals throughout and making the necessary corrections, and by calculating the total sum square difference instead of that for "within treatments". Using the same notation as before the following table gives the identities for the respective parts of the sum square differences.

	Sum Square Differences.	Degrees of Freedom.
1. Total	$\sum_{1}^{16}(x-\bar{x})^2 = \sum_{1}^{16} x^2 - S.\bar{x}$	$16 - 1 = 15$
2. Rows	$4\sum_{1}^{4}(x_r-\bar{x})^2 = 4\sum_{1}^{4} x_r^2 - S.\bar{x}$	$4 - 1 = 3$
3. Columns	$4\sum_{1}^{4}(x_c-\bar{x})^2 = 4\sum_{1}^{4} x_c^2 - S.\bar{x}$	$4 - 1 = 3$
4. Treatments ..	$4\sum_{1}^{4}(x_t-\bar{x})^2 = 4\sum_{1}^{4} x_t^2 - S.\bar{x}$	$4 - 1 = 3$
5. Residual	1 − (2+3+4)	$15 - 9 = 6$

The complete arithmetic is given below.

Total :—

Squares	324	576	400	676	
	1,156	3,600	900	1,296	
	484	576	2,116	784	
	1,444	1,296	1,600	3,844	
					21,072
		$S.\bar{x} = 544 \times 34 =$			18,496
					2,576

Rows.	*Columns.*	*Treatments.*
484	784	784
1,600	1,296	1,296
900	1,156	1,225
1,936	1,444	1,369
4,920	4,680	4,674
19,680	18,720	18,696
18,496	18,496	18,496
1,184	224	200

The residual sum square difference is then 2,576 − (1,184 + 224 + 200) or 968, as was found by Maskell's method.

This figure may be directly calculated, and by doing so, a clear conception of partitioning the variation between the various factors is obtained. An appreciation of the significance of the residual, or error, figure is the key to understanding the principles of analysis of variances in field experiment data.

In the analysis already done, the first reading 18, has a row mean of 22, a column mean of 28, a treatment mean (A) of 28 and the general mean is 34. The total variation due to the difference between 18 and 34 has been assessed, *i.e.* $(x - \bar{x})^2$ and from this the variation due to row, column and treatment respectively, *i.e.* (22 − 34), (28 − 34), (28 − 34) has been subtracted.

The part of the sum square difference therefore, which has not been calculated directly, is expressed by :—

$$\sum_{1}^{16} e^2 = \sum_{1}^{16} \left[(x-\bar{x}) - (x_r-\bar{x}) - (x_c-\bar{x}) - (x_t-\bar{x}) \right]^2 \quad \ldots\ldots\ldots *$$

e.g.: $(18-34) - (22-34) - (28-34) - (28-34) \quad = 8^2 = 64$

The expression may be simplified thus :—

$x - x_r - x_c - x_t + 2\bar{x}$	$= e$	e^2
18 − 22 − 28 − 28 + 2 × 34	= 8	64
24 − 22 − 36 − 36 + 2 × 34	= − 2	4
20 − 22 − 34 − 35 + 2 × 34	= − 3	9
26 − 22 − 38 − 37 + 2 × 34	= − 3	9
34 − 40 − 28 − 28 + 2 × 34	= − 1	1
60 − 40 − 36 − 36 + 2 × 34	= 15	225
30 − 40 − 34 − 35 + 2 × 34	= − 4	16
36 − 40 − 38 − 37 + 2 × 34	= −10	100
22 − 30 − 28 − 28 + 2 × 34	= − 5	25
24 − 30 − 36 − 36 + 2 × 34	= − 9	81
46 − 30 − 34 − 35 + 2 × 34	= 14	196
28 − 30 − 38 − 37 + 2 × 34	= 0	0
38 − 44 − 28 − 28 + 2 × 34	= − 2	4
36 − 44 − 36 − 36 + 2 × 34	= − 4	16
40 − 44 − 34 − 35 + 2 × 34	= − 7	49
62 − 44 − 48 − 37 + 2 × 34	= 13	169
		968

* For proof of the identity, refer to reference 5.

The sum of the sixteen e^2 is 968, the figure arrived at by difference, and one which assesses exactly the variation not due to treatment, or to the different fertility levels of rows and columns. It is this residual, or random variation which makes our replicated experimental lay-outs necessary.

Summary.

No attempt is made here to explain the general analysis of field experiment data. Detailed descriptions and worked examples of this are given in references 1, 3 and 4, cited below. The point made is that the total variance may be partitioned according to the various factors, each part being directly calculable. The random, or residual variance is shown to be a definite part of the total variance.

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WEST INDIAN NOTES

Compiled by the Advisory Department of the Imperial College of Tropical Agriculture.

The Sugar Industry.

The prospects for the 1932 sugar crop throughout the islands are very much more encouraging than they were at the end of 1931. This remarkable recovery and return to normal production is due almost entirely to the effect of ample rains which, in contrast to the drought of 1930-31, most of the islands have enjoyed during the second half of the year. Barbados promises to have a record crop and Antigua and St. Kitts good average crops.

The most outstanding development in recent years of methods of soil tillage in preparation for the sugar crop in these islands is due to the enterprise shown by the Antigua Sugar Factory, Limited, which, a few months ago, purchased a Gyrotiller. This implement, manufactured by Messrs. Fowler & Co., is capable of stirring the soil to a considerable depth and, in one operation, to plough, cultivate, harrow and ridge. It is propelled by a 150 H.P. Diesel engine and is mounted on caterpillar tracts. It does its work in a dry soil and judging from the excellent tilth obtained on the several hundred acres on which it was used in Antigua, increased crops may confidently be expected. It is understood that the Gyrotiller is to be sent out to Trinidad, where a group of sugar estates have combined to give it a trial.

The extended use of this implement has given rise to a number of agronomic problems which are engaging the close attention of the planters and of the agricultural department. Amongst these may be mentioned such questions as the method of draining, the need for cross holing, the treatment of the soil from time of ploughing to planting, the possibility of the change of the planting season, the manurial treatment, the use of green dressings, and of the varieties of cane best suited to the changed soil conditions as a result of a much more thorough soil preparation.

The increased use during the last few years of power drawn implements on sugar estates in the West Indies is undoubtedly having a steady cumulative effect on the sugar output and more especially is important in that it may lead to a reduction in costs of production.

There is ample evidence that sugar growers are following with much interest the various experiments now being conducted by the agricultural departments in several of the islands. The work of the Barbados Department, particularly in regard to the raising of sugar cane seedlings is being much appreciated. Similarly, experiments on the manurial requirements of sugar cane which are being conducted in all of the most important sugar islands are being keenly followed. There is some danger, in the quest for economy and for cheapening costs of production, that the sound old-time practice of applying liberal dressings of pen manure to sugar-cane fields is being neglected. The giving up of this or of any other well established agricultural practice should, however, only be agreed to after careful experiments have proved the superiority of the newer methods.

The importance of careful plant selection and disinfection when planting fields of sugar-cane is another matter that cannot be overlooked. Messrs. Box, Collins and Warneford working in Antigua have recently stated that considerable success has followed the use of a five per cent. solution of formalin as a disinfectant. This treatment coupled with close selection and the rejection of borer infected plants is becoming a general practice in Antigua, and is worthy of trial elsewhere. The formalin solution is easily prepared and the treatment is claimed to be economical.

* * *

Sea Island Cotton.

The Sea Island cotton industry is still in a severe plight. This is particularly so in Montserrat, Nevis and St. Vincent, where the cotton is a major industry and to a lesser degree in Barbados, St. Kitts and Antigua, where the crop may be regarded as of secondary importance. Cotton growers are following the advice of reducing their acreages under the crop, but in Montserrat and Nevis where there are no alternative crops such reduction in acreage is likely to lead to a grave economic crisis. Nevertheless the growers hope that this sacrifice will ultimately lead to an improved demand.

In those islands where the crop was sown early it suffered severely from repeated attacks of cotton worms. The pink boll worm has also been more in evidence than for several years past. In many cases the depredations of these insects have increased costs of production and thus added to an already difficult situation. The rainy weather, beneficial in so many other ways, made the effective control of the leaf worm by dusting, almost impossible. The quality of the reaped cotton in Montserrat shows a very distinct improvement following on the measures taken last year to prevent the planting of inferior seed. The area under cultivation in those islands which plant in the autumn, has been very materially reduced.

In Antigua and Nevis the standard of cotton was good and showed a marked degree of purity. Arrangements have been made to maintain this improvement in future years. Dr. Harland visited Montserrat in this connection last November and reported that the measures advocated after his visit of last year had been carried out in a satisfactory manner.

With funds provided by the Imperial Government a Cotton Ginnery has been purchased by the Government in Nevis, which will be operated for the benefit of the peasantry. This operated for the first time this year and the 88 bales shipped from the Ginnery have been sold at a price which enabled a small second payment to

be made over the five cents per pound of seed cotton advanced to the growers at the time of delivery. The Ginnery will continue working during the coming season.

The question of holding a Conference of cotton growers has been receiving the attention of those concerned during the last few months and the Commissioner of Agriculture has recently visited the Leeward Islands with the object of discussing the situation with those concerned.

* * *

Fruit and Vegetable Storage.

Exports.—Bermuda has continued to be the principal market for mangoes and avocado pears. Shipments to 31st October last, of these fruits and boxed limes from the two principal fruit exporting islands were as follows :—

	Mangoes Crates.	*Avocados Crates.*	*Limes Boxes.*	
Dominica	1,245	638	654	(Bermuda and Canada.)
St. Lucia	4,823	2,281	2,158	(Bermuda, Canada and U.K.)

Small shipments of mangoes and avocados were also made from St. Vincent and Grenada and of barrelled green limes to New York from St. Lucia and Dominica. Up to the end of October, Dominica also shipped 504 cases of oranges (mostly navels), 113 cases of grapefruit and 34 cases of lemons, this fruit being sent principally to Bermuda where it yielded good prices. During November a further 1,100 cases of oranges and grapefruit were exported, which, as the Bermuda market was limited, were sent mostly to the Maritimes. It is expected that a further 4,000 cases will be shipped during the season. This fruit is packed at the Government Marketing Depot where facilities have been provided by the Government in the shape of a newly erected cold storage plant and of citrus packing machinery recently imported by Mr. J. E. Knowlton. Small quantities of other fruits and vegetables, such as tangerines, pineapples, green coconuts, peppers and egg-plants have also been exported to Canada, Bermuda and the United Kingdom.

It is early yet to state definitely the prospects for the coming vegetable export season, but St. Vincent is expecting to ship to Canada some 15,000 crates of tomatoes and St. Kitts-Nevis 10,000 crates. As planting is still in progress in Montserrat it is difficult to estimate the crop but it should approximate about 10,000 crates. There should in addition be 1,000 to 2,000 crates of string beans exported from the islands, apart from smaller quantities of egg-plants, sweet potatoes, &c. The vegetable exports from Antigua, Dominica, St. Lucia and Grenada are expected to be relatively small. With regard to inter-island trade, Dominica has shipped much cull citrus fruit, Barbados in particular taking a fair quantity.

Cold Storage Plants.

The cold storage plants at St. Kitts, Nevis, Montserrat, Dominica and St. Lucia are now in operation while the St. Vincent and Grenada ones should soon be completed. The Dominica plant is the only one which is being used to any extent for fruit storage and as such is proving of great value for storing packed fruit prior to shipment. The others are expected to function during the coming vegetable, mango and avocado seasons.

Cold Storage of Tomatoes.

Fear has been expressed that some of the benefits of precooling fruits might be lost through "heating" and "sweating" but preliminary experimental work by Dr. C. W. Wardlaw of the Low Temperature Research Station, Imperial College of Tropical Agriculture, indicates that small quantities of tomatoes do not suffer to any extent under these conditions. To decide this point definitely, however, the results of the bulk shipments during the coming season must be awaited. There are further complications on account of the poor quayside facilities (lack of cranes, trolleys, &c.), and generally primitive lighterage which are to be found in the islands, while financial considerations would prohibit the handling of fruit by the use of insulated containers, and insulated lighters. The transfer of fruit from cold storage to lighters should be effected as quickly as possible. It has been suggested that the use of oiled liners in the crates might reduce "heating" and "sweating", and it is hoped to investigate this point during the next few months.

Packing Sheds.

Government packing sheds are being established in most of the islands. The question of their management and staffing is also receiving consideration. By packing in the sheds with labour employed, trained and supervised by the Packing Shed Managers, greater uniformity in the quality of the export product should be ensured. The most recent development in this connection is the Packing Shed in St. Lucia, the erection of which, with the help of a Colonial Development Fund grant has almost been completed. This is a spacious building situated alongside the new cold storage plant.

Inspection of Fruit for Export.

Several of the Fruit Exportation Ordinances (and Rules) already in operation are in process of revision. Up to the present, whilst exports from St. Vincent have been mostly packed at the Government Packing Shed, they have not been controlled by law but a proposed Ordinance is now under consideration which is expected soon to be in operation. With the help of a travelling Marketing Officer it is hoped that the interpretation of these Ordinances as regards grading, &c., will be more uniform in the future.

Land Settlement Schemes.

Some progress has been made with the land settlement scheme in Antigua and Nevis. In the Green Castle Settlement, Antigua, the majority of the holdings have already been allotted. In a few instances the quality of the work done by the allottees is satisfactory, but many of them have not yet had time to settle down. They have, however, the advantage of being situated near the Experiment Station from which they can be provided with good planting material. They are also in close contact with the model allotment run for their benefit and which they are encouraged to visit. The officers of the Department pay regular visits to the settlement and are available for advice and help. The Mathews Estate, another property purchased by Government for settlement is being surveyed and should be ready for allotment early in 1932. In Nevis, the Government has completed the purchase of Low Ground Estate, a property of close on 500 acres, which is being surveyed and sub-divided into convenient lots.

Schemes for land settlement in St. Vincent and St. Lucia are still under consideration.

* * *

Livestock Industry.

The report of Mr. R. E. Montgomery, M.R.C.V.S., Adviser in Animal health to the Secretary of State for the Colonies, on a visit to the West Indies, British Guiana and Bermuda, has been published and is available for reference and should be read by all interested in live stock problems.

Mr. Montgomery was unfortunately able to spend only a few hours in each of the Windward and Leeward groups. Each Island is in much need of a visit from an experienced Veterinary Officer who could spend sufficient time to lay down a suitable livestock policy. This industry is passing through a difficult period owing largely to the cutting down in the number of animals kept on the sugar estates. It is only with the greatest difficulty that sales of good working animals can be effected. Nevis and the Virgin Islands have considerable numbers of well grown oxen old enough to be broken in for work. There is also a glut in the small mule market in these islands. A remarkable improvement in conditions is to be observed in the stock in the islands which suffered so much from the drought last year. The offspring of the two well bred Zebu bulls in Nevis may now be seen in the pastures of the island.

Mr. Montgomery expresses the opinion that "there is no question but that the natural pasture lands of most West Indian colonies can be improved, and the results of manuring sour grass (*Andropogon pentussis*) in Barbados, have been most beneficial. The work of the Cambridge School of Agriculture and that done in South Africa, upon light and heavy stocking, close grazing, &c., is worthy of repetition". This subject requires careful work and experimentation under West Indian conditions. Undoubtedly the effect of artificial manures on such grasses as Guinea, Elephant and Sour, is very beneficial, but in several instances it is only with the greatest difficulty that good permanent pastures can be maintained indefinitely under tropical conditions. In a recent experiment, the writer has seen a pasture manured before last year's dry season which, instead of yielding a crop of grass, gave nothing but a heavy growth of weeds immediately after the rains had fallen.

* * *

Miscellaneous Information.

Dr. Harland, Cotton Adviser to the Commissioner of Agriculture, paid a brief visit of inspection to Montserrat in November.

Both Mr. F. G. Harcourt, Agricultural Superintendent, Dominica, and Mr. C. A. Gomez, Curator, Botanic Station, Montserrat, have now returned from leave.

Mr. F. L. Squibbs has been seconded from Dominica to act as Assistant Director of Agriculture in Seychelles. Mr. Squibbs left Dominica on 19th December.

An Agricultural and Industrial show was held in St. Vincent on 11th December. A district show organised by the District Agricultural Officer was held in Portsmouth, Dominica, in November last.

Mr. G. A. Jones, Assistant Commissioner of Agriculture, left Trinidad by s.s. *Lady Hawkins* and after paying visits to Antigua, St. Kitts, Montserrat, Dominica and St. Lucia, returned by s.s. *Path Finder* on 13th December.

Mr. H. A. Ballou, Commissioner of Agriculture and Professor of Entomology, left Trinidad by s.s. *Dominica* on 10th November and after visiting Antigua, St. Kitts and Montserrat, returned by s.s. *Lady Drake* on 5th December.

Mr. A. C. Shill, Marketing Officer, after spending six weeks in Dominica, proceeded to St. Lucia where he remained for a week before he revisited Dominica. During November and December he paid official visits to St. Kitts, Nevis, Montserrat, St. Vincent and Grenada.

The purchase of the Montserrat Botanic and Experiment Station, which was the property of a private company has been completed and is now vested in the Government of the Island. The area of this station is now about 14 acres.

The Montserrat Marketing Depot has been reorganised and an Advisory committee appointed to assist the Officer-in-Charge to run it.

After a period of over 40 years, the care of the Botanic Station in Antigua has been handed over to the Keeper of Prisons. The change has been thought necessary in view of the urgent need for economy. The new experiment station started in Greencastle, Antigua, has been laid down in a very attractive manner.

The experiment station in St. Kitts has been enlarged and a variety and distance planting experiment laid down.

A VARIETY TEST OF SUGAR-CANE.

By R. Cecil Wood, M.A. (Camb.) and
D. D. Paterson, B.Sc. (Edin.)

Introductory.

This experiment, planned to test the relative merits of fifteen varieties of Sugar Cane, was started in October, 1925 (1), on the farm of the Imperial College of Tropical Agriculture, Trinidad. The soil on the area selected may be described as a yellow silty loam with, in places, patches of gravel. It lies on the dividing line separating the marine alluvial plains to the south from the wash soils off the hills to the north. The plasticity and cohesiveness are low, and the soil readily breaks up into fine particles, so that, if over-cultivated, it has a tendency to set to a puddled condition after heavy rains. It is acid in reaction, and of low fertility and has responded well to the manures used. The soil over the experimental area is far from uniform in character, but it is hoped that the effects of this irregularity have been largely eliminated by the system of statistical analysis adopted.

The crop received careful cultivation throughout and was well treated from the manurial point of view. Pen (farmyard) manure, at the rate of ten tons to the acre, was applied in the furrows at the time of planting (2). The first ratoons received, besides the trash, 2 cwt. to the acre of sulphate of ammonia. The treatment of the subsequent crops was more liberal: the second ratoons received a total of 4 cwts. to the acre of sulphate of ammonia, sulphate of potash, superphosphate, and blood meal in equal portions; the third ratoon had a similar dressing, except that the quantity of blood meal was doubled, and that of sulphate of potash halved.

The rainfall for the period under report is given below :—

Table I.—Rainfall.

	1925-26.	1926-27.	1927-28.	1928-29.	1929-30.
June ..	7.62	9.90	13.08	8.51	10.35
July	7.38	7.43	8.93	6.15	9.65
August ..	14.03	12.89	10.77	9.15	7.87
September ..	8.35	14.42	12.10	5.67	5.59
October ..	*6.01	4.17	6.85	3.62	2.76
November ..	6.32	6.24	7.54	11.60	7.88
December ..	5.73	6.74	10.37	6.04	1.25
January ..	1.36	7.30	6.04	1.36	3.62
February ..	.63	7.94	1.45	.69	1.04
March ..	.17	1.65	1.41	**.70**	**.61**
April ..	.43	**9.10**	3.27	.92	2.34
May	3.50	9.10	**1.43**	7.46	2.07
Total ..	61.53	96.88	83.24	61.87	55.03

* Month of planting.
Months of harvest in thick heavy type.

The first growing season was marked by exceptionally continuous and evenly distributed rains, which produced a heavy crop of cane, but owing to the unusual wet weather at harvest time, (April, 1927), the crop ripened poorly and milled badly (46 tons of cane, with 9.2 per cent. sugar). In the second season, though the rainfall was almost as heavy, it was more suitably distributed, and the dry weather in the early months of 1928 ripened up the crop better, so that, though the yield was poor (33 tons), the average proportion of sugar to cane was 12.5 per cent. The second ratoon crop enjoyed a good growing season, and, taking full advantage of the manure it received, produced a heavy crop (48 tons) with a high percentage of sugar, 13.5 per cent. The yield dropped considerably (22 tons) in the third ratoon crop which probably suffered rather from the dry weather of the previous December : the percentage of sugar was the highest of the series (13.9).

Table II.

Block I.	Block II.	Block III.	Block IV.
B. 156	St. Croix 12/4	Ba. 6032	T. 911
Bourbon	B. 6835	Ba. 11569	T. 899
Tanna	B.H. 10/12	Wh. Trans.	T. 301
B. 6835	Uba	Sealey S.*	Ba. 6032
St. Croix 12/4	Bourbon	Badilla	Ba. 11569
B.H. 10/12	Tanna	T. 301	Wh. Trans.
Uba	B. 156	T. 899	Sealey S.*
Wh. Trans.	Ba. 11569	T. 911	Badilla
T. 911	Ba. 6032	B. 156	Uba
T. 899	Badilla	St. Croix 12/4	Bourbon
T. 301	Sealey S.*	B. 6835	Tanna
Ba. 6032	Wh. Trans.	B.H. 10/12	B. 156
Ba. 11569	T. 911	Uba	St. Croix 12/4
Sealey S.*	T. 899	Bourbon	B. 6835
Badilla	T. 301	Tanna	B.H. 10/12

* Sealey S. means Sealey Seedling.

The area chosen for the experiment was a slightly skew rectangle, or parallelogram. This was divided transversely into four equal sized blocks, lying side by side. Each block was subdivided into 15 plots and, as there were 15 varieties to test, this allowed each variety to be replicated four times, *i.e.*, once in each block. The plot size was 40 ft. by 10 ft. or approximately .009 of an acre. This is considerably below the optimum for experimental purposes, but the large number of plot yields, and consequently of Degrees of Freedom on which the estimate of error is based, compensates for this to some extent. The arrangement of the varieties in the blocks is shown in Table II. It will be seen that the three Trinidad seedlings are always adjacent, and T. 899 is always the centre of the three : Bourbon and Tanna occupy the same relative

(1) The experiment was initiated by Professor Dash, B.S.A., and was taken over by the first author in November, 1927. The second author is responsible for the statistical consideration of the results.

(2) An experiment reported in *Trop. Agriculture*, Vol. V, p. 134, indicated this to be the best method of planting.

position in all blocks. Otherwise the distribution appears to be of the controlled random type and it is considered that Fisher's analysis of variance method may fairly be used.

Varieties.

The particular selection of canes used in the experiment was made for a number of reasons.

At the time when the experiment was started, B. 156 was probably the standard cane in the island: its place has now largely been taken by B.H. 10/12. St. Croix 12/4 is a seedling cane which was originally produced in Santa Cruz by Langford Smith working with Bovell. Both the above, B.H. 10/12 and St. Croix 12/4 are descended from B. 6835 as the female parent, and though B. 6835 is not of great value as a field cane, it was included as being of interest to plant breeders. Ba. 6032 and Ba. 11569 are both first class Barbados seedlings of considerable popularity; the former produces a very heavy weight of cane of rather moderate quality. In order to secure a fairly representative number of the traditional varieties, Bourbon was included and White Transparent (Crystallina or Cuba), as the cane which replaced Bourbon when the latter collapsed with disease. Badilla is the well-known cane of Queensland, where it is practically the only kind planted, and has been a success in some of the West Indian islands, while Tanna is a well known Yellow Caledonian cane. The three Trinidad seedlings, T. 911, T. 899, and T. 301 are comparatively recent productions and are not yet widely grown. The Sealey Seedling is an old Barbados variety discovered by a planter of that name; it was, like Bourbon, included in the series to afford a comparison between the older and the newer varieties. Uba requires no description; in spite of its hard stem and poor milling qualities, it occupies a large and probably increasing area owing to its hardiness, resistance to disease and heavy cropping qualities. It has been introduced more than once, but it was not until recently that modern milling enabled it to be crushed economically.

Statistical Method.

(*a*) *Yield of Cane.*

The cane yield from each plot for the four harvests was weighed at the time of delivery at the factory. These plot yields were then converted to tons per acre. In consideration of the small size of the plot and the fact that a difference of a few pounds of cane from any plot would alter considerably the yield expressed in tons per acre, statistical analysis was carried out on the plot yields calculated to the nearest ton per acre. The experiment consisted of four blocks of 15 plots each, so that the Total Variance can be split up into that due to variety, that due to block, and that due to error. It is on this error variance that the measure of significance is based. Each year's data were first of all analysed separately. In every case, in order to keep the squares of deviations as low as possible, yields were tabulated as deviations from an assumed mean and the necessary correction factor applied in calculating the final estimate of the sums of squares. In addition to being simpler and quicker, this system is more accurate than squaring the deviations from the actual means calculated to so many places of decimals. Significances were then worked out and the behaviour of the 15 varieties year by year compared. The mean yield per acre for each variety for the four-year period was next calculated and the data analysed in order to compare the total crop yields of each variety. This gave some very suggestive results, and to verify these, it was decided to calculate an estimate of error based on the 16 plot yields obtained from any one variety during the four-year period. To eliminate seasonal differences, plot yields were compared with the means of their own particular years only, and the estimate of errors thus calculated were summed. Thus if X_1, X_2, X_3, X_4, each having D Degrees of Freedom, are the error variances for the four years taken singly, the error variance for the whole period will be $\frac{X_1+X_2+X_3+X_4}{4}$. The Degrees of Freedom corresponding to this error variance will be 4D. Owing to the larger number of plot yields taken into consideration, the variance due to error was lower than that calculated from the Mean annual yields. It is a valid measure of error for the particular four-year period in question, and the application of it confirmed the suggestive conclusions previously obtained.

(*b*) *Yield of Sugar.*

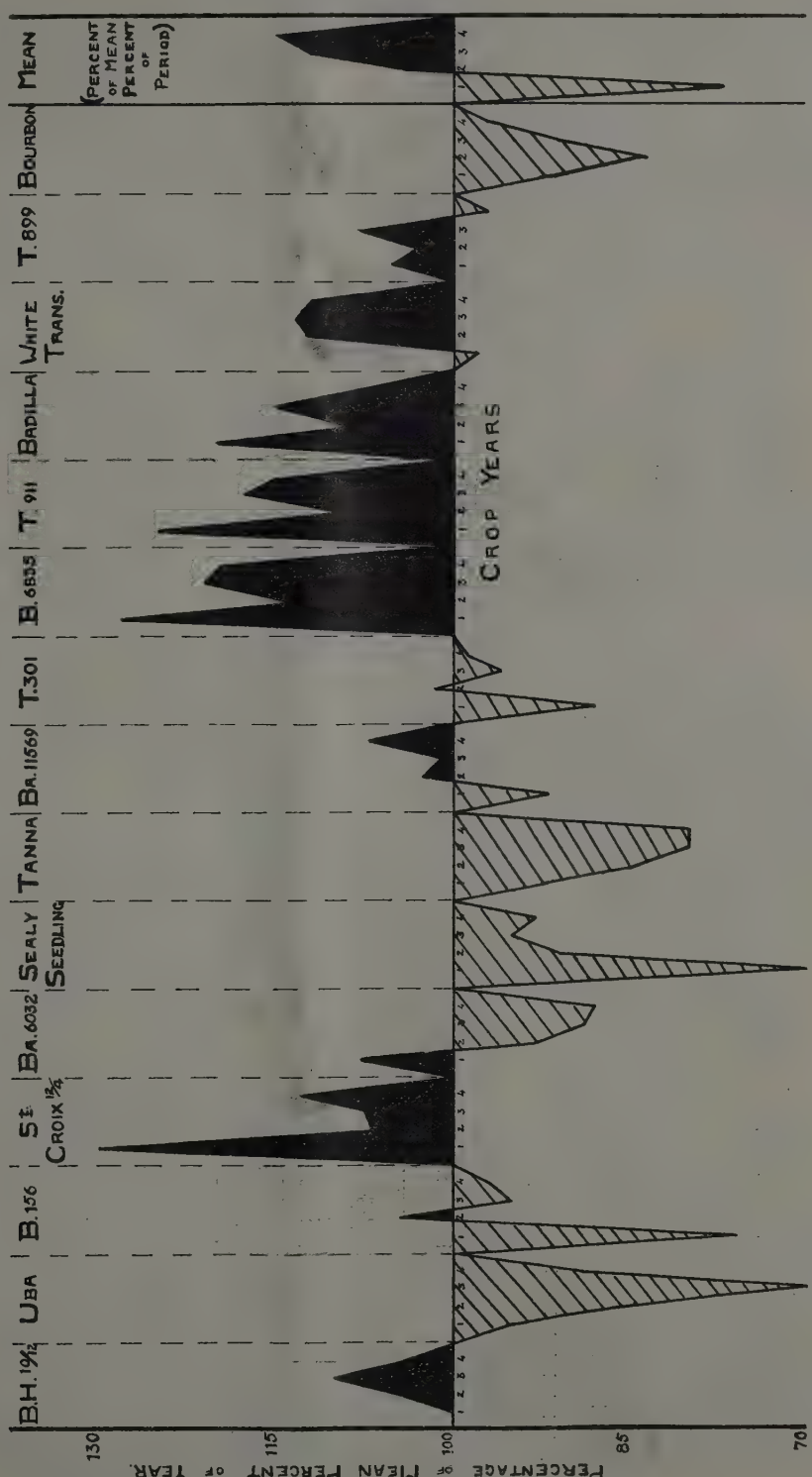
The cane was milled at the experimental Sugar Factory on the estate. This factory of course could not handle so many small quantities separately, and the question of obtaining accurate analyses of the sugar content of the cane from each plot each year has presented some difficulty. In the first year, 50 average canes were selected from each plot and were put through a small laboratory hand-mill. This method of sampling was not considered altogether satisfactory, owing to subjective errors likely to occur in the selection of the canes to be milled. In the second and subsequent years it was decided to pick two representative stools per plot, and use all the canes from each stool for analysis. With the kind co-operation of the Professor of Sugar Technology, these stools were analysed under his direction.

The analyses gave figures for purity of juice and the percentage of sucrose in cane. In calculating the actual sugar yield per plot, 95 per cent. sucrose extraction, and 99 per cent. boiler house efficiency were assumed, and the produce calculated as 96° sugar. A reduction of six from purity was also made to allow for the weaker crushing of the test mills. Then by applying this reduced purity figure to Winter's Formula, the yield of sugar per plot was obtained as follows:—

$$\frac{\text{Yield of Cane} \times \text{Percentage Sucrose in Cane (from analysis)} \times .95 \text{ (Sucrose extraction)} \times .99 \text{ (Boiler House efficiency)} \times \frac{1.4-.40}{\text{purity (Winter's Formula)}}}{.96} = \text{(Degrees Sugar)}$$

FIG. I.—CANE YIELDS
TONS PER ACRE.
0
40
80
120
160
200
SIGNIFICANCE (R = .05)
29·4
B.H. 10/12
UBA
B.156
S² CROIX 12/4
BA. 6032
SEALY SEEDLING
TANNA
BA. 11569
MEAN
T. 301
B. 6835
T. 911
BADILLA
WHITE TRANS.
T. 899
BOURBON
3RD RATOON
2ND RATOON
1ST RATOON
PLANT CANE
T911
FIG. II.—SUGAR YIELDS
TONS PER ACRE.
0
5
10
15
20
25
SIGNIFICANCE (P. = .05)
3·76
B.H. 10/12
UBA
B.156
S² CROIX 12/4
BA. 6032
SEALY S
TANNA
BA. 11569
MEAN
T. 301
B. 6835
T. 911
BADILLA
WHITE TR.
T. 899
BOURBON

FIG. III.- RELATIVE SUGAR PERCENTAGE



The calculated yield of sugar from each plot was expressed in so many 1/10th tons per acre. The data for the sugar yields were analysed statistically in the manner applied to the cane yields.

Results.

To enumerate the plot yields of cane and sugar year by year and to show the corresponding statistical calculation is not essential to this report, which is mainly concerned with the ultimate conclusions. Therefore, only the mean annual yields for each variety and the standard errors are quoted below. These show clearly the grounds on which the conclusions are based. For those sufficiently interested, appendices have been added showing all the cane and sugar yields, and details of the statistical analysis applied to the 1926-27 sugar yields as a sample of the system adopted.

1925-27. (Plant Cane.)

Cane.			Sugar.			
Variety.	Mean Yield in tons per acre.	S. E. of Difference.	Variety.	Mean Yield in tons per acre.	S.E. of Difference.	Sugar Yield as a percentage of Cane Yield.
Ba. 6032 ..	70.8	8.3	Ba. 6032 ..	7.00	.98	9.9
B.H. 10/12	59.0		St. Croix 12/4 ..	6.08		11.9
B. 156 ..	55.5		B.H. 10/12	5.40		9.2
Sealey Seedling	52.8		Badilla ..	4.83		11.0
Tanna ..	51.3		Tanna ..	4.35		8.5
St. Croix 12/4 ..	51.0		Uba ..	4.25		8.7
Uba ..	49.0		**Mean ..**	**4.24**		**9.2**
Bourbon ..	46.5		Bourbon ..	3.95		8.5
Mean ..	**46.3**		B. 156 ..	3.90		7.0
			Ba. 11569	3.85		8.5
Ba. 11569	45.5		T. 911 ..	3.83		11.5
Badilla ..	44.0		B. 6835 ..	3.73		11.7
Wh. Trans.	38.3		Wh. Trans.	3.45		9.0
T. 301 ..	34.8		Sealey Seedling	3.35		6.3
T. 911 ..	33.5		T. 899 ..	3.00		9.7
B. 6835 ..	32.0		T. 301 ..	2.65		7.6
T. 899 ..	31.0					

1927-28. (1st Ratoon.)

Cane.			Sugar.			
Variety.	Mean Yield in tons per acre.	S.E. of Difference.	Variety.	Mean Yield in tons per acre.	S. E. of Difference.	Sugar Yield as a percentage of Cane Yield.
St. Croix 12/4 ..	44.0	7.2	St. Croix 12/4 ..	5.90	.68	13.4
Uba ..	43.5		B.H. 10/12	5.10		13.2
Sealey Seedling	42.8		B. 156 ..	4.90		13.1
B.H. 10/12	38.8		Sealey Seedling	4.85		11.3
Tanna ..	38.3		Uba ..	4.68		10.8
Ba. 6032	37.5		Ba. 6032 ..	4.33		11.6
B. 156 ..	37.3		**Mean ..**	**4.09**		**12.5**
Mean ..	**32.8**		Tanna ..	4.05		10.6
			B. 6835 ..	4.03		14.2
T. 301 ..	29.8		Wh. Trans.	3.93		14.1
Ba. 11569	28.5		T. 301 ..	3.80		12.7
B. 6835 ..	28.3		Ba. 11569	3.65		12.8
Wh. Trans.	28.0		T. 911 ..	3.60		13.7
T. 899 ..	26.8		T. 899 ..	3.45		12.9
T. 911 ..	26.3		Badilla ..	2.83		13.6
Bourbon	21.5		Bourbon ..	2.23		10.4
Badilla ..	20.8					

1928-29. (2nd Ratoon.)

Cane.			Sugar.			
B.H. 10/12	66.5	7.8	B.H. 10/12	9.93	1.20	14.9
Uba ..	60.5		St. Croix 12/4 ..	8.60		14.5
B. 156 ..	60.3		B. 6835 ..	8.08		16.4
St. Croix 12/4 ..	59.5		B. 156 ..	7.70		12.8
Sealey Seedling	55.3		Sealey Seedling	7.10		12.8
Tanna ..	52.8		Ba. 11569	6.78		13.6
Ba. 6032	49.8					
Ba. 11569	49.8		**Mean ..**	**6.48**		**13.5**
B. 6835 ..	49.3		Ba. 6032 ..	6.28		12.6
Mean ..	**48.1**		T. 301 ..	6.05		12.9
			T. 911 ..	5.95		15.9
T. 301 ..	46.8		Uba ..	5.73		9.5
T. 911 ..	37.5		Tanna ..	5.73		10.8
T. 899 ..	35.8		Badilla ..	5.25		15.5
Badilla ..	33.8		T. 899 ..	5.23		14.6
Wh. Trans.	33.3		Wh. Trans.	5.05		15.2
Bourbon	30.5		Bourbon ..	3.75		12.3

1929-30. (3rd and Final Ratoon.)

Cane.			Sugar.			
Uba ..	35.0	5.7	St. Croix 12/4 ..	4.40	.82	15.7
B. 156 ..	31.5		Uba ..	4.30		12.3
B.H. 10/12	29.3		B. 156 ..	4.23		13.5
St. Croix 12/4 ..	28.0		B.H. 10/12	4.20		14.4
Sealey Seedling	26.5		Ba. 11569	3.88		14.9
Ba. 11569	26.0		Sealey Seedling	3.43		12.9
Tanna ..	23.5		B. 6835 ..	3.23		16.6
Ba. 6032	22.8					
Mean ..	**22.5**		**Mean ..**	**3.12**		**13.9**
			T. 301 ..	3.00		13.8
T. 301 ..	21.8		T. 911 ..	2.95		15.9
B. 6835 ..	19.5		Ba. 6032 ..	2.78		12.2
T. 911 ..	18.5		Tanna ..	2.60		11.1
T. 899 ..	16.8		T. 899 ..	2.25		13.4
Badilla ..	14.5		Badilla ..	2.18		15.0
Wh. Trans.	12.8		Wh. Trans.	2.00		15.5
Bourbon ..	10.3		Bourbon ..	1.38		13.4

1925-27 (Plant Cane).

These results are generally significant on the one per cent. value of Z. Throughout the calculations, a difference greater than twice the S.E. of differences has been taken as a significant one. This means that significances are based on a probability of .05; any differences which do not attain this level have been ignored.

Ba. 6032 is the outstanding yielder both of cane and sugar. Other good cane yielders are B.H. 10/12, Sealey Seedling, Tanna and St. Croix 12/4. B.H. 10/12 and St. Croix 12/4 are also good sugar yielders, the high sugar percentage in St. Croix 12/4 being particularly noteworthy.

1927-28 (1st Ratoon).

Sugar yields are significant on the one per cent. value of Z., but cane yields only on the five per cent. value.

Cane yields are not conclusive, but the yields of St. Croix 12/4, Uba and Sealey Seedling, suggest good varieties.

In sugar yield, St. Croix 12/4 is the best. Ba. 6032, the outstanding variety of the previous year, is only average in both cane and sugar yields. B.H. 10/12 is again among the heavy sugar yielders.

1928-29 (2nd Ratoon).

Results are significant on the one per cent. value of Z.

B.H. 10/12 is the only variety significantly better than the mean for both cane and sugar yields St. Croix 12/4 and B. 156 again suggest themselves as good all-round varieties. Uba gives a distinctly good cane yield, but a low sugar content. B. 6835, on the other hand, has given only an average cane yield, but a distinctly favourable sugar yield, due to its high sucrose percentage.

1929-30 (3rd and Final Ratoon).

Results are significant on the one per cent. value of Z.

Uba is the outstanding cane yielder and consequently, in spite of its low sucrose content, it has given a relatively good yield of sugar also. Of the remaining varieties, St. Croix 12/4, B. 156 and B.H. 10/12 all appear to be good yielders both for cane and sugar. B. 6835 is once again notable for its high sugar percentage.

Period 1925-30: Combined Results of Four Crops.

Cane.			Sugar.			
Variety.	Mean Annual Yield in tons per acre.	S.E. of Difference.	Variety.	Mean Annual Yield in tons per acre.	S.E. of Difference.	Sugar Yield as a percentage of Cane Yield.
B.H. 10/12	48.4	3.7	St. Croix 12/4 ..	6.25	.47	13.7
Uba ..	47.0		B.H. 10/12	6.10		12.8
B. 156 ..	46.2		B. 156 ..	5.18		11.2
St. Croix 12/4 ..	45.6		Ba. 6032..	5.10		11.3
Ba. 6032			B. 6835 ..	4.77		14.8
Sealey Seedling	45.2		Uba ..	4.74		10.1
Tanna ..	44.3		Sealey Seedling	4.68		10.6
Ba. 11560	41.5		Ba. 11560	4.54		12.1
**Mean ..	37.5		**Mean ..	4.48		12.0**
T. 301 ..	33.3		Tanna ..	4.18		10.1
B. 6835 ..	32.3		T. 911 ..	4.08		14.1
T. 911 ..	29.0		T. 301 ..	3.88		11.7
Badilla ..	28.3		Badilla ..	3.77		13.3
Wh. Trans.	28.1		Wh. Trans.	3.60		12.8
T. 899 ..	27.6		T. 899 ..	3.48		12.6
Bourbon ..	27.2		Bourbon ..	2.83		10.4

Results are significant on the one per cent. value of Z.

For Cane Yields, B.H. 10/12, Uba, B. 156, St. Croix 12/4 and Ba. 6032 are all significantly above the average. Out of these, St. Croix 12/4 and B.H. 10/12 stand supreme on account of their heavy sugar yields. Over the four-year period, they are not only better sugar yielders than the mean of all the varieties, but are actually significantly better than any of the others. In the analysis of the four harvests separately, they appear every year without exception among the good cane and sugar yielders. This experiment can therefore be said to prove conclusively that, with the given environmental conditions of soil and season, St. Croix 12/4 and B.H. 10/12 are the best of the 15 varieties tested. As regards their relative merits, it might reasonably be said on general grounds that St. Croix 12/4 is probably a slightly sweeter cane than B.H. 10/12, but with a shade lower yielding capacity, though this statement cannot be definitely proved from the data recorded.

On account of its hardiness, disease resistance, and high yielding capacity, Uba might be considered a suitable cane for certain localities. It gives, however, a relatively low sucrose percentage and its fibrous character makes it very difficult to mill. It could only be recommended for use in areas where the conditions were not suited to the growth of the other good varieties. Ba. 6032 owes its relatively high total yield largely to the very heavy first year's harvest of plant cane. If this heavy first crop is a constant characteristic of this cane, it might be suitable for a non-ratooned or single ratooned crop. Its sugar percentage is only average. B. 156 appears to be a good steady yielder, but with a sucrose content rather under normal.

At the other extreme, Bourbon, T. 899, White Transparent, Badilla and T. 911 all give significantly low cane yields. Examination of each year's data separately, only serves to confirm this conclusion. With the sole exception of Bourbon in the first year, they have yielded less and frequently significantly less cane than the Mean of the year. Some of them are rich in sugar and consequently their sugar yields are not so relatively poor. This high sugar percentage cannot be said to compensate for their low yielding capabilities, and these five canes can be ruled out as definitely unsatisfactory. It is interesting that three of them are old established varieties which have found favour elsewhere: Badilla is practically the only cane grown in Queensland, White Transparent is the most popular cane of Cuba, and Bourbon was at one time almost universal in the West Indies till disease wiped it out.

Conclusions.

The results stated in the last two paragraphs are depicted graphically in Figs. 1 and 2, which deal with the cane yields and the sugar yields respectively. To allow of easy comparison, the varieties in both diagrams are arranged in order of cane yield from left to right and in each diagram the mean is indicated and the amount of difference necessary to be significant.

There is no doubt about the outstanding superiority of the two canes B.H. 10/12 and St. Croix 12/4, which may be taken to yield the same quantity of sugar, though in the case of the St. Croix seedling, the amount of cane to produce this is possibly smaller. The peculiarity of Uba is also clearly shown: it is definitely among the heaviest yielders, but its poor quality puts it down about the average in the production of sugar, and it is, of course, expensive to mill.

The diagrams also demonstrate the differences shown by the canes in regard to their ratooning quality. If, for instance, a case arose where it was only possible to take a single crop of cane, Ba. 6032 would suggest itself, for it gave the highest yield of sugar and cane of any of the varieties at the first harvest. The effect of the rather heavy dose of manure that was applied to the third crop (2nd ratoon) is also shown clearly both on quantity and quality of cane, and it would further appear that this effect only lasted for a single season though it must be remembered that this third crop enjoyed very favourable growing weather. The quality of the cane, *i.e.*, the percentage of sugar to cane, continued to improve to the end as shown by the following Table (*see* Fig. 3).

This is in conformity with general experience.

Crop.	Sugar content expressed as a per cent. of Mean per cent. of whole period.
Plant	77
1st ratoons	104
2nd ratoons	112
3rd ratoons	116

This diagram also shows that the fault with most of the newer seedlings, such, for instance, as Ba. 11569, B. 6835, T. 911 and T. 899, is their inability to crop heavily, so that though many of them are particularly sweet, they do not compare commercially with older favourites. Evidently the tendency of the sugar cane breeder is to overstress the quality factor and pay too little attention to the yield. It may be surmised that future progress will be made in the direction of producing canes of greater cropping capacity.

The experiment generally supports the practice that prevails in Trinidad of taking only two ratoon crops, for it will be seen that in spite of a heavy manurial dressing and in spite of the improvement in quality, the sugar production fell to a very low figure, in the third ratoon crop.

APPENDIX I. **Plot Yields of Cane in tons per acre.**

Variety.	1925-27 (Plant Cane).					1927-28 (1st Ratoon).					1928-29 (2nd Ratoon).					1929-30 (3rd Ratoon).					Mean annual yield for period.
	Blocks				Mean.	Blocks				Mean.	Blocks				Mean.	Blocks				Mean.	
	I	II	III	IV		I	II	III	IV		I	II	III	IV		I	II	III	IV		
B.H. 10/12 ..	52	65	53	66	**59.0**	38	41	31	45	**38.8**	50	48	97	71	**66.5**	24	31	28	34	**29.3**	**48.4**
Uba ..	42	47	51	56	**49.0**	35	45	38	56	**43.5**	57	54	52	79	**60.5**	47	25	31	37	**35.0**	**47.0**
B. 156 ..	84	43	34	61	**55.5**	63	25	29	32	**37.3**	84	41	43	73	**60.3**	48	17	26	35	**31.5**	**46.2**
St. Croix 12/4	42	59	37	65	**51.0**	47	57	32	40	**44.0**	60	72	53	53	**59.5**	29	42	19	22	**28.0**	**45.6**
Ba. 6032 ..	56	68	100	59	**70.8**	35	32	51	32	**37.5**	42	44	70	43	**49.8**	21	24	29	17	**22.8**	**45.2**
Sealey Seedling ..	59	51	44	57	**52.8**	42	43	40	46	**42.8**	59	51	48	62	**55.3**	30	24	23	29	**26.5**	**44.3**
Tanna ..	67	39	49	49	**51.3**	44	29	45	35	**38.3**	60	46	55	50	**52.8**	21	21	28	24	**23.5**	**41.5**
Ba. 11569 ..	55	48	42	37	**45.5**	26	27	32	29	**28.5**	46	54	51	48	**49.8**	23	25	34	22	**26.0**	**37.5**
T. 301 ..	40	33	30	36	**34.8**	26	37	27	29	**29.8**	45	54	43	45	**46.8**	20	26	18	23	**21.8**	**33.3**
B. 6835 ..	37	37	22	32	**32.0**	32	38	20	23	**28.3**	36	63	35	63	**49.3**	21	28	17	22	**19.5**	**32.3**
T. 911 ..	28	39	32	35	**33.5**	27	23	25	30	**26.3**	35	36	35	44	**37.5**	16	12	20	26	**18.5**	**29.9**
Badilla ..	23	47	34	62	**44.0**	29	15	23	16	**20.8**	42	22	30	41	**33.8**	14	8	11	25	**14.5**	**28.3**
Wh. Trans. ..	42	41	23	47	**38.3**	29	23	35	25	**28.0**	33	31	42	27	**33.3**	40	10	16	11	**12.8**	**28.1**
T. 899 ..	31	41	23	29	**31.0**	27	25	23	32	**26.8**	36	38	35	44	**35.8**	17	14	12	24	**16.8**	**27.6**
Bourbon ..	65	31	52	38	**46.5**	29	21	18	18	**21.5**	36	24	24	38	**30.5**	17	6	11	7	**10.3**	**27.2**

APPENDIX II. **Plot Yields of Sugar expressed in tons per acre.**

Variety.	1925-27 (Plant Cane). Blocks I	II	III	IV	Mean.	1927-28 (1st Ratoon). Blocks I	II	III	IV	Mean.	1928-29 (2nd Ratoon). Blocks I	II	III	IV	Mean.	1929-30 (3rd Ratoon). Blocks I	II	III	IV	Mean.	Mean annual yield for period.
B.H. 10/12 ..	3.8	4.5	4.7	8.6	**5.40**	5.0	5.9	4.4	5.1	**5.10**	8.0	6.9	14.1	10.7	**9.93**	3.8	3.7	4.5	4.8	**4.20**	**6.16**
Uba ..	3.4	3.6	4.8	5.2	**4.25**	4.3	4.0	3.7	6.7	**4.68**	5.3	4.8	4.7	8.1	**5.73**	5.8	2.8	3.5	5.1	**4.30**	**4.74**
B. 156 ..	6.2	2.9	3.0	3.5	**3.90**	7.0	3.5	4.5	4.4	**4.90**	10.9	5.6	4.8	9.5	**7.70**	7.2	2.5	4.1	3.1	**4.23**	**5.18**
St. Croix 12/4	4.4	7.4	4.2	8.3	**6.08**	5.5	7.7	4.7	5.7	**5.90**	8.8	10.2	7.9	7.5	**8.60**	4.0	6.8	3.1	3.7	**4.40**	**6.25**
Ba. 6032 ..	6.1	8.2	8.6	5.1	**7.00**	4.1	4.2	6.6	3.4	**4.33**	4.9	5.7	9.0	5.5	**6.28**	2.6	2.8	3.4	2.3	**2.78**	**5.10**
Sealey Seedling ..	3.5	3.4	3.3	3.2	**3.35**	5.1	4.1	4.5	5.7	**4.85**	8.0	8.6	5.1	6.7	**7.10**	4.1	3.0	2.8	3.8	**3.43**	**4.68**
Tanna ..	5.8	2.9	3.4	5.3	**4.35**	4.5	3.4	4.7	3.6	**4.05**	6.0	5.0	6.2	5.7	**5.73**	2.5	2.2	2.8	2.9	**2.60**	**4.18**
Ba. 11569 ..	3.6	4.5	4.2	3.1	**3.85**	3.5	3.2	4.4	3.5	**3.65**	5.6	7.5	6.4	7.6	**6.78**	3.4	3.7	4.8	3.6	**3.88**	**4.54**
T. 301 ..	2.8	2.3	3.0	2.3	**2.65**	3.1	5.1	3.0	4.0	**3.80**	5.1	6.7	6.3	6.1	**6.05**	2.5	3.7	3.0	2.8	**3.00**	**3.88**
B. 6835 ..	4.7	4.6	2.5	3.1	**3.73**	4.3	5.4	2.6	3.8	**4.03**	5.7	10.3	6.0	10.3	**8.08**	3.4	4.1	1.1	4.0	**3.23**	**4.77**
T. 911 ..	3.2	4.2	4.0	3.9	**3.83**	3.6	3.1	3.8	3.9	**3.60**	5.7	6.2	5.8	6.1	**5.85**	2.7	2.0	3.4	3.7	**2.95**	**4.08**
Badilla ..	3.5	5.8	5.2	4.8	**4.83**	4.1	2.1	3.2	1.9	**2.83**	7.3	3.7	4.7	5.1	**5.25**	2.3	1.2	1.8	3.4	**2.18**	**3.77**
Wh. Trans. ..	4.5	3.3	2.3	3.7	**3.45**	4.3	3.1	5.1	3.2	**3.93**	5.2	1.8	6.0	1.2	**5.05**	2.2	1.6	2.5	1.7	**2.00**	**3.60**
T. 899 ..	3.3	4.0	2.6	2.1	**3.00**	3.6	2.9	2.9	4.4	**3.45**	5.5	3.9	5.0	0.5	**5.23**	2.8	2.1	1.4	2.7	**2.25**	**3.48**
Bourbon ..	7.4	2.9	3.5	2.0	**3.95**	2.7	2.4	1.9	1.9	**2.23**	3.9	3.5	2.7	4.9	**3.75**	2.3	0.9	1.4	0.9	**1.38**	**2.83**

APPENDIX III. **Statistical Analysis of Sugar Yields of the Plant Cane (1927 Harvest).**

All yields are expressed in one-tenth tons per acre less 40.

Variety.	Blocks I +	I −	II +	II −	III +	III −	IV +	IV −	Total. +	Total. −	Square of Plot Yields. I	II	III	IV	Square of Variety Totals.	Square of Block Totals.
B. 156 ..	22			11		10		5		4	484	121	100	25	16	
Bourbon ..	34			11		5		20		2	1156	121	25	400	4	
Tanna ..	18			11		6	13		14		324	121	36	169	196	
B. 6835 ..	7		6			15		9		11	49	36	225	81	121	
St. Croix 12/4	4		34		2		43		83		16	1156	4	1849	6889	
B.H. 10/12		2	5		7		46		56		4	25	49	2116	3136	
Uba ..		6		4	8		12		10		36	16	64	144	100	
Wh. Trans ..	5			7		17		3		22	25	49	289	9	484	
T. 911 ..		8	2		0		1		7		64	4	0	1	49	
T. 899 ..		7		0		14		19		40	49	0	196	361	1600	
T. 301 ..		12		17		10		17		56	144	289	100	289	3136	
Ba. 6032 ..	21		42		46		11		120		441	1764	2116	121	14400	3844
Ba. 11569 ..		4	5		2			9		6	16	25	4	81	36	2025
Sealey Seedling		5		6		7		8		26	25	36	49	64	676	49
Badilla ..		5	18		12		8		33		25	324	144	64	1089	1764
Totals ..	111	49	112	67	77	84	133	91	316	174	2858	4087	3401	5774	31932	7682
	+62		+45		−7		+42		+142			16120				

Mean $= +\frac{142}{15} = +2.37$

Total Sum of Squares
$= 16120 - 142 \times 2.37 = 15784$

Sum of Squares due to Variety
$= \frac{31932}{4} - 142 \times 2.37$
$= 7647$

Sum of Squares due to Blocks
$= \frac{7682}{15} - 142 \times 2.37$
$= 176$

Sum of Squares due to Error
$= 15784 - (7647 + 176)$
$= 7961$

Analysis of Variance.

Due to.	Degrees of Freedom.	Sum of Squares.	Mean S. of S.	½ Loge.
Total ..	59	15784	—	—
Variety ..	14	7647	546.2	1.9606
Block ..	3	176	58.6	.8132
Error ..	42	7961	189.6	1.4712

Difference of ½ Loge. for Treatment and Error .. $= .4894$
Value of Z for degrees of Freedom 14 and 42 and Probability .05 $= .31$
Do. do. .. .01 $= .45$
Therefore significance clearly exists.
Standard error of variety totals $= \sqrt{189.6 \times 4} = 27.5$
Standard error of mean yield of each variety expressed in tons per acre $= \sqrt{\frac{27.5}{40}} = .69$
Standard error of Difference between varietal Means .. $= .98$

VEGETATIVE PROPAGATION.

[*A discussion of its application and advantages with special reference to tropical orchard and plantation crops.*]

By E. E. Pyke, B.Sc., A.R.C.S. (Lond.).

Introduction.

The application of entirely vegetative methods of propagation has in recent years become of great importance in temperate orchard practice, and the researches of horticultural experimental stations in Europe and America have demonstrated the great advantages, both from a scientific and a commercial standpoint, which have accrued from planting standardised material obtained by vegetative means. There seems every reason to believe that similar advantages might be anticipated from the application, in a wider field, of vegetative propagation to several tropical crops, but the realisation of this will depend primarily on the discovery of methods of vegetative propagation suitable to commercial application, and secondly on the interest shown by the planters themselves in the use of vegetatively raised stock. This article has been prepared to summarise and to afford a discussion of the most important work which has been done in recent years, as most of the literature may be unavailable to the tropical grower.

Seedling and Vegetative Propagation.

When a plant is propagated from seed, it stands in a different relation to the parent plant than do the other products of its growth, such as the leaves, twigs, roots and buds. In nearly all plants the "germ" of the seed is a sexually formed structure, produced as the result of a fusion between two sexual cells known as gametes, one of which may have been contributed by another plant. This process involves a recombination of inheritance factors and produces a new individual, with characters usually differing from those of either parent. Even if a plant were self-pollinated, the seedling would not, in general, grow into a plant exactly duplicating the parent in all its characters. Actually, if a crop were habitually self-pollinated for several generations, the progeny would tend to come true to seed, but this systematic breeding rarely, if ever, occurs in orchard crops. Moreover such pure lines would, with these crops, take many years to breed experimentally owing to the long generation periods.

This production of variation in the offspring is characteristic of sexual reproduction, and it is believed by some botanists to play an important part in the production of new forms in nature (20, page 320). The hybridisation made possible by sexual reproduction is of great importance to the horticulturist in the production of new types. Some new varieties arise as "bud sports" without any sexual process occurring, but the majority are the result of hybridisation. It is impracticable in slow breeding plants such as most tree crops, to continue breeding from the initial hybrid until the desired new qualities are fixed so that they come true to seed. Instead, a method of multiplying the first hybrid unchanged must be used and this may be achieved by one of the methods of vegetative propagation. Both vegetative propagation and seedling reproduction are processes in which either juvenile parts, or in vegetative propagation, parts capable of rejuvenation, are removed from a plant and used to establish another plant. The fundamental difference is that in seedling reproduction the new plant originates in a single fertilised cell, whereas in vegetative propagation the new plant develops from multicellular tissues in which no fertilisations take place. The vegetative propagation of a new plant takes place by the "germination" of almost any part of a plant except the seed, by placing the part selected in a suitable environment, either before or after severing it from the plant. There are several fundamental methods used, but not all are suitable for any particular type of plant. The practical details of technique differ considerably for different subjects, according to their capacities for regeneration, and each new variety tried may require its own special treatment.

A practical classification of methods may be made into :—

(1) Rooting processes, and

(2) Grafting processes.

The first group of methods aims at the production of new roots and shoots upon plant parts such as stems, roots, or even leaves, the new root and shoot system being eventually established as a new plant. This group may be further subdivided according to whether the new roots are formed while the organ is still retained on the parent plant, or after it has been removed as a cutting.

Thus there are :—

(1) Layering, stooling and allied processes such as "bagging" or "marcotting" (9).

(2) Cuttings, which may be either hardwood or softwood stem cuttings, root cuttings or leaf cuttings.

The second main group consists of the method of grafting, budding and approach grafting, sometimes collected under the general term "graftage". There are many modifications of practical methods, but the basic principle is always that of inducing the tissues of two separate plants to grow together, in order to form one composite plant. In grafting and budding a part of one plant, either a small piece of stem or a piece of bark including a bud, is removed and placed in contact with the cambial tissue of the other plant so that the tissues grow together. In approach grafting two plants are made to grow together while each is still on its own roots, by removing the bark from portions of the stems to expose the cambium, and binding the two stems together with the bared surfaces in contact. It is not necessary to enter into details of the different

methods of vegetative propagation as they are described in horticultural books on the subject (13, 14, 15). Unfortunately, the literature dealing with vegetative propagation of tropical crop plants is very scanty and is confined almost entirely to budding and grafting methods (6, 7). The importance of the root-stock on the performance of a fruit tree seems to have received practically no attention from tropical workers, and the problems of propagation of tropical root-stocks remain practically a virgin field.

Advantages.

(a) *Uniformity.*

Vegetative propagation essentially extends a genetic type unchanged, no sexual process intervening. Thus, no matter how hybrid the individual selected for propagation may be, the vegetative offspring preserves its identical genetic constitution. Such a family of plants, all of one genetic type, is called a *clone* (Gr. klonos, a twig). Hence, in a clonal plantation, the variability between the plants, due to differences in genetic constitution, is eliminated, and the only variability is that due to the environment. In some crops, notably cacao, it is known that the variability in a normal seedling population is very high owing to the very hybrid constitution of the plants, and a considerably smaller variability is to be expected in a clonal population. On the other hand, some crops which possess a purer genetic make-up, show a comparatively small variability in a seedling population, but such crops are rare among tropical perennials.

In practice, two aspects of variability are to be considered, firstly, variability in *type of crop*, and secondly, variability in *yield of crop*. The fixation of fruit type by some form of vegetative propagation is essential in temperate fruit crops such as apples and pears, in which seedlings produce fruit of very poor quality. The variety to be propagated is usually budded or grafted on to a stock. In tropical fruit crops, similar methods are sometimes used, but the practice is not universal. Certain types of citrus are propagated by budding, and "improved" mango and avocado pear varieties also are vegetatively propagated. In cacao, which does not produce a directly edible fruit, the necessity of a uniform fruit type is less obvious but equally certain; the propagation of a uniform good bean type would be of great value, as cacao, after picking, undergoes a series of technical processes in which uniformity of bean in size, chemical composition, texture, thickness of shell, &c., is highly desirable. It cannot be too much stressed, that in cacao, uniformity may represent an important factor of quality.

The reduction of variability in yield is probably quite as important, as reliable scientific work is greatly complicated by a crop showing high variability. The lay-out of a manurial trial, for example, is made very much simpler and cheaper if the material to be worked with is as uniform as possible. This can only be realised by having clonal material throughout. The advantages to the commercial grower are no less. The poor bearing trees in a plantation may be regarded as being merely a load upon the more productive trees; their presence increases production costs per acre, and renders intensive cultivation impossible. This is particularly the case with cacao, where a large proportion of the trees consists of poor, or very poor, bearers (8).

The root-stock upon which a variety is budded often has a marked influence upon the yielding capacity of the scion (11). In fact the variation of yield when seedling stocks are employed may actually be as great as if the trees were entirely seedlings. If uniform yielding material is required, the variety must either be established on its own roots by rooting cuttings or stool shoots, or else it must be budded on to a clonal root-stock. Only if the root system is clonal can a reasonable uniformity of yield be obtained.

(b) *Extension of Environmental Range of a Crop.*

The propagation of uniform types may enable a crop to be grown under conditions of soil and climate which would be unsuitable for the growth of the majority of the original mixed seedling population. Thus, a particular plant may be noticeable by its greater resistance to drought, cold, or disease, than its neighbours and will on propagation yield a clone, incorporating this property, and capable of successful cultivation in a situation where the original types would fail. When top-worked varieties are considered, there is additional control over environment in the possibility of selecting a suitable clonal root-stock. Hansen (10), dealing with apple growing in the prairie north-west of United States of America and Canada, where the winter conditions are very trying for fruit trees, gives two factors for success with orchard fruits:—

(i) A hardy variety.
(ii) A hardy stock for budding and grafting.

The ordinary commercial seedling apple stocks were found to be subject to root killing. Seedling stocks of the Siberian Crab, "Pyrus baccata", were found to be much more resistant and certain "Pyrus baccata" seedling hybrids were very satisfactory. However, Hansen emphasises the advantages of being able to obtain a clonal root-stock of a hardy type:—"It would be a great advance over the present method of growing seedlings, to root these vigorous "Pyrus baccata" hybrids from cuttings. The ideal future apple stock may be some f_1 hybrid derived in part from "Pyrus baccata" grown from cuttings to ensure uniformity". (Hansen, *Proc. IX Hort. Conf.*, p. 308, 1930.)

Tropical crops do not have to contend with winter cold, but the similar problem of drought resistance occurs. A series of clonal root-stocks, in cacao for example, worked with scion clones, would yield valuable information on the question of the degree of drought resistance of different cacaos, and its correlation with cropping and premature wilting of crop.

Sands (18) gives a good example of the increase of the environmental range of a tropical crop by vegetative propagation in the cultivation of Cinchona in Java :—" The ' Ledgeriana ' types of Cinchona can only be successfully grown on their own roots on virgin land, of which there is a very limited area now available. Practically all the fields when replanted are put under selected ' Ledgeriana ' strains grafted on *Cinchona succirubra*, which has a much stronger root system than ' Ledgeriana ' and grows well over a wider range of territory and in poorer soils".

(*c*) *Increase of Vigour of Weakly Types by working on to Suitable Clonal Root-Stocks.*

In a budded or grafted plant, that is, a worked plant, the root-stock frequently has a marked effect on the performance of the scion (11). The growth of any plant may be regarded as a balanced process between vegetative and reproductive activity, and under given conditions, a definite ratio exists in the expenditure of effort between these two activities. In worked stocks the type of root-stock seems to be an important controlling factor of this balance ; different root-stocks with the same scion variety produce quite different growth habits and fruiting capacities in the scion. A variety which does not do very well on its own roots in a certain situation may be improved in general vigour by a root-stock which modifies any tendency to produce too much " wood " or fruit. The work of the breeder often produces such types, which possess valuable qualities, but which are not sufficiently vigorous to be grown well on their own roots, and require the assistance of a suitable root-stock. Thus, the apple variety " Cox's Orange Pippin " is a delicate subject on its own roots and neither crops well nor makes good vegetative growth ; in particular, it is readily attacked by apple canker. If worked on to a suitable dwarfing stock, however, the habit of growth is made more sturdy and the tree also crops better. In tropical crops, at the present day, delicate " improved varieties " are rare, the plants are all very near to the " wild " form. Improvement by selection and breeding has not been going on for centuries, as in the temperate pome fruits (23). Hence, most of the types one might select for varieties would be hardy. However, breeding work will soon bring out the necessity for the mothering of new varieties by sturdy root-stocks. In cacao, the more delicate types such as *Theobroma Cacao*, var. *Criollo*, *Th. pentagona*, and possibly *Th. Cacao* x *Th. pentagona* hybrids, may be rendered hardier by working on to clonal root-stocks.

(*d*) *Propagation of Sterile Types.*

A sterile type may be defined as one which cannot be propagated by seed. Either no seed at all may be produced, or the seeds, if formed, may be incapable of germination or further growth. If such a variety is to be propagated, some vegetative method must be used.

An edible fruit variety may be esteemed on account of its absence of seeds. Seedless oranges, grapefruit, sapodillas, &c., are well-known. In the citrus fruits such types have frequently been propagated as clones, such as the Marsh seedless grapefruit and the Washington navel orange. Although seedless sapodillas sometimes occur, no method of vegetative propagation has so far been used to extend such varieties.

(*e*) *Early Maturity.*

Frequently a vegetatively raised sapling will come into bearing sooner than a seedling of corresponding age. Also, a bud from a seedling, " mothered " by budding on to an older stock, often bears much sooner than the seedling itself. This is not always the case, however ; in some crops, notably apples, each fertilisation seems to introduce a " juvenile period " of a definite time, during which the variety will not fruit, whatever the nutritional conditions. If the juvenile period of a seedling can be shortened by working on to a stock, it is of great value in breeding investigations, as fruit is produced earlier and the delay between generations is appreciably lessened.

Disadvantages of Vegetative Propagation.

(*a*) *Initial Cost.*

The view is often expressed that it would cost much more to plant up a plantation of a crop such as cacao, for example, with vegetatively propagated plants, than with seedlings. This question of initial cost, strictly speaking, is purely an economic one, and cannot legitimately be brought against vegetative propagation as a horticultural method. At present, with a plantation crop such as cacao, planting is usually done by putting in seeds at stake, which certainly establishes a plant very cheaply. Nursery plants could never be produced sufficiently cheaply to compete in first cost with this method of planting, and also, contract planting, as practised in Trinidad would not probably be satisfactory in establishing these expensive plants. However, it is unfair to quote increased cost per acre in planting as an argument against planting up with a high yielding clonal stock instead of with seed, for if the clonal material yields consistently a higher crop than the seedlings, it will in consequence yield a higher rate of interest. In general, the overhead costs of an estate are little affected, if at all, by the type of material planted, and since it costs about the same to maintain good stock as to maintain bad, it is a generally accepted principle of horticulture that adequate expenditure on planting material is the truest economy in the long run.

(*b*) *The Root System.*

It is a widespread belief among planters that a tree raised from a rooted cutting or sucker fails to form a good root system, and that in consequence, the sapling does not develop into a healthy bearing tree. In particular, with cacao trees, it is stated that when they have been raised from detached basal suckers—" chupons "—they do not develop a tap-root, and that therefore they will be of no value, as, for some reason, great importance seems to be placed on the presence of a tap-root. Granted that no vegetatively raised individual can develop a true tap-root, in cacao the supposition

that basal suckers do not develop main roots, which function exactly similarly, is untrue; most "chupons" which have rooted on the trees have a main root when they are young, and if this subsequently decays it must indicate that the soil conditions are not suited to its persistence.

In work at the Imperial College of Tropical Agriculture on the vegetative propagation of cacao, both rooted shoots from stools and from layered stems, have been found to develop sturdy main roots, similar to the tap-roots of seedlings. Plants raised from this material should form quite as good root systems as nursery seedlings.

Recent work at East Malling (12) has shown that the type of root system developed by a stock is constant, irrespective of any particular method of propagation, under uniform soil conditions. Even in different soils, in an experiment with some of the East Malling apple stocks it was found that each stock still developed its characteristic type of root system, with sufficient constancy to be identifiable in the different soils. Only the extent of development of the root systems was markedly affected by the type of soil. It is true that the layered stocks used did not develop tap-roots, but adequate root systems, both for assimilation and anchorage, were formed—"the main scaffolding of roots spread out in the top 18 inches of soil; but vertical roots often descend from these scaffold roots to a depth of many feet". *

(c) *Senescence and Degeneration.*

This heading covers the remaining major criticism which must be considered. Does continued vegetative propagation necessarily result in any lack of vigour, either vegetative or sexual, in the plant? On *a priori* grounds one would think that it must do so, for in vegetative propagation there is no sexual act to intervene with the production of a new individual; the act of vegetative propagation merely extends in space an individual which normally has a finite existence, for every tree seems to become feeble with age, and eventually to die (16). How can this act be expected to result also in an indefinite extension in time? The conception is not difficult when the probable causes of senescence in a perennial plant are considered. Even in a tree which is reckoned to be 1,000 years old, the canopy of leaves is renewed every year or every few years, and most of the active root system is of young growth. There is no need to postulate any degeneration or tiring of the protoplasm of the meristems to explain the general moribund aspect of an old tree, the explanation probably lies in the difficulty which the tree finds in nourishing its young growing parts—the conducting path for the sap is long and much of it is rendered inefficient by air blocks. The cambium of the trunk cannot form new tissue sufficient to overcome the difficulty, and is itself working under stressed conditions, for respiration must be a serious problem in an old encrusted trunk. Further, fungi enter the trunk [illegible] pruning wounds and cause decay, first in the path and eventually in the more vital tissues. Thus the senility may be brought on by a progressive failure of the separate parts of the organism to work harmoniously together, and eventually, when one part breaks down, the whole tree as an organism dies. If young tissue from an old tree is removed and put in a favourable environment (the act of vegetative propagation) the resulting growth, after a time, is in every way comparable to that of similar tissue taken from a tree in the prime of life. Stout (21) gives examples of the persistence of vigour upon vegetative propagation. Cuttings of Lombardy poplar taken from slow growing twigs of a large tree, root poorly, and those which do root, grow poorly for a time. But after two or three years of nursery treatment the stock becomes vigorous and makes fine sucker branches that are excellent for propagation as cuttings.

Cacao is a tree which may be regenerated from basal suckers even though the old tree be moribund. There seem to be no grounds for supposing that these "secondary" trees are less vigorous or fruitful than the original seedlings; in fact many of the best bearing trees in the older Trinidad orchards are probably regenerated "chupons", themselves many decades old, from trees which would now be aged at least 150 years.

However, it must be granted that the question as to whether senile degeneration does or does not occur in clones, is not satisfactorily answered even to-day. For over a century the "Degeneration" problem has been discussed, without conclusive evidence coming forward either for or against, but, as in most controversial subjects, the field of inquiry has been littered with much unsatisfactory evidence, based on faulty observations or faulty deductions, or both. On the whole, true cases of senile degeneration remain unproved. The cases cited have always had some explanation in terms of disease or environmental unsuitability. Even if work of the future does show that, for certain crops at least, some degeneration must occur on continued vegetative propagation, the fact will not be of much importance. Even if the old varieties were still as vigorous as ever, the public taste would forsake them for new ones, the admirable properties of which would be supplemented by new varietal names, which, suitably chosen, would most probably enhance the appeal to novelty.

The subject of senile degeneration as it stands to-day, is admirably discussed by A. P. C. Bijhouwer in a review of the literature recently published by the Imperial Bureau of Fruit Production (*Journ. Pom.*) (2).

Apparent Senescence.—This is quite a different thing from the true senescence discussed above, but is much more likely to occur in practice with large-scale vegetative propagation. It is often called "reversion", "running out", and other terms suggestive of degeneration. The deterioration may arise, in general, in two ways, although

* Hatton, H. G. and Rogers, W. S.—The Importance of the Root System, *E.M.B. Publication*, No. E. 32, page 7.

both may play a part. The first way is by the infection of the clone with some disease, which is passed on by vegetative propagation. The virus diseases are the ones which must be especially looked for to cause this trouble; they are systemic, cause morphological and physiological changes, often indeed suggestive of a reversion to the "wild" state, and they exhibit no trace of any organic parasite. The classic example of a virus disease causing a general deterioration of a vegetatively propagated crop, is the "reversion" disease of black currants. This virus is transmitted by a Mite, which itself causes the malformity known as "big-bud". The virus also spreads through the branches of the black current bushes, and cuttings taken from affected twigs spread the disease. By this means the disease was generally disseminated in England, causing immense loss to the growers. The only remedy was found to lie in establishing fresh propagation nurseries from carefully selected healthy material, together with rigorous "rogueing" of any diseased shoots which might appear.

The other way in which deterioration of a stock may occur is by the accidental introduction of extraneous stocks, usually chance seedlings, when the nursery plants are lifted; this is likely to occur in a plant which fruits in the nursery, such as the raspberry. With raspberries the canes fruit, and seedlings spring up, which may not be obviously different in appearance from the clonal stock, but which develop into plants with poorer fruiting capacities. Prevention of this contamination must also be sought by clean cultivation and "rogueing". In addition to these seedling rogues, objectionable types may appear even in rigidly maintained clones of some plants, by the production in the clone of bud sports or branch mutations. This is particularly liable to occur in some citrus types such as grapefruit. Shamel (19) notes the occurrence of undesirable branch mutations in various citrus fruits, and stresses the danger of the propagation of such poor types. There is always the possibility in a variety which is unstable, such as the Marsh seedless grapefruit, or the Washington Navel orange, that special "improved" forms might be sold, which would be merely unstable chimaeras, liable to revert, on part or whole of the tree, to the normal form.

(*d*) *Problems of Sterility within a Clone and between Clones.*

The planting up of an orchard with uniform clonal material may introduce problems of sterility which would not arise in a plantation of seedlings. Many cultivated clonal varieties of orchard crops are partly or wholly self-sterile, that is, they do not set fruit with their own pollen. Vegetative propagation of such a type does not remove this condition; all the members of the clone will have the same degree of fertility or sterility to one another as the original plant possessed when self-pollinated. With such sterilities as male sterility, and self-incompatibility (4, 5) seed production depends on a suitable cross-pollination, which would not take place if self-incompatible clonal material were planted up in blocks away from other types. Thus, unless a clone is found to be reasonably self-fertile, it should not be planted exclusively in blocks, but with rows of some other cross-fertile variety chosen to ensure successful mutual cross-fertilisation. In a crop, such as cacao, where the seed is the part required, partial sterility is serious in that few seeds are developed. On the other hand, in most fruit crops the edible portion is not the seed, and is often developed in the absence of seeds, as in bananas and seedless citrus fruits, and in these cases self-incompatibility may not matter.

With cacao, as it exists at present, the question of self-sterility would not appear to be of much importance, for the crop seems to have a high degree of self-fertility, according to Harland and Frechville, about 70 per cent. of the pods set are self-pollinated. However, cacao must be considered to be a virtually wild crop, and the best yielding trees which exist at present probably would not bear comparison with so-called "improved varieties", which will no doubt be produced as systematic selection and breeding work progresses (7). These improved varieties may be expected to exhibit various degrees of self-incompatibility, and even, in some cases, imperfect cross-compatibility amongst each other, due to doubled incompatibility factors (5). In varieties where these effects occur, suitable mutually compatible varieties must be planted with them to obtain effective fertilisation.

Summary.

(1) A fresh plant may generally be raised by two methods; from seed, or from some fragment of a parent plant other than a seed, or, as in budded seedling stocks, by a combination of both methods. Seed propagation involves a sexual act, and produces a definitely new individual which may or may not closely resemble the parent type. In most orchard crops, the offspring usually show considerable variation. Vegetative propagation is not a sexual process, and does not produce a new type, it merely extends the original parental type.

(2) Vegetative methods may be used to propagate either a complete plant, or a scion plant which is worked on to another stock. Complete plants or root-stocks are raised from rooted cuttings, stool shoots, or layers. Scion clones may be raised by budding or grafting the desired variety on to stocks, which may be either seedlings or members of a clone.

(3) The extension of a type by vegetative propagation makes possible a degree of crop uniformity, both of yield and of quality, which is rarely attained in a seedling population. This uniformity is of great advantage both in the scientific and the commerical fields. In scientific work a high intrinsic variability in the experimental material obscures the variability caused by the experimental conditions; for the grower, the presence of low yielding types increases the overhead costs of the plantation. To obtain the highest degree of uniformity of yield, the plants should be entirely clonal, both stock and scion.

(4) The isolation of individual plants, chosen for special qualities, such as cold or drought tolerance, and their subsequent vegetative propagation, can

increase the range of cultivation of a crop by bringing in districts which are unsuited to the average type. This is analagous to the breeding of hardy strains of wheat, where, however, vegetative propagation is not necessary to fix a type, as pure genetic lines are readily raised.

(5) In temperate horticulture it is a standard practice to work certain varieties on to vigorous stocks, thus improving either their vegetative growth or cropping capacity, or both. In tropical crops, modern breeding work will probably produce similar delicate varieties which require the assistance of a hardy root-stock.

(6) Some desirable fruit varieties are highly sterile and thus cannot be propagated by seed. In these fruits, vegetative propagation must be used to extend the variety.

(7) A bud from a seedling may often be made to grow and bear fruit sooner than the original seedling, by working it on to a stock. This hastening of maturity would be of great value in speeding up genetic work on an orchard crop.

(8) The first cost of a vegetatively raised nursery plant will usually be higher than that of a seedling planted at stake. However, the increased yield expected from such nursery plants should amply justify the initial increased expenditure.

(9) A tap-root is by definition an organ peculiar to a seedling. However, exactly similarly functioning roots can grow on vegetatively raised plants. It is highly probable that in most orchard crops, after a certain age, the root systems of trees which grew from seedling root-stocks and those which grew from vegetative root-stocks will be found to be indistinguishable. Even in seedlings it is doubtful whether the primary tap-root is persistant in a mature tree.

(10) The question of senescence always arises in connection with the vegetative extension of varieties. At the present day, the occurrence of true senescence in clones on continued vegetative propagation is neither proved nor disproved. However, even if some senescence were proved to occur, it would not affect very much the policy of orchard crop growers, who normally would wish to plant new varieties from time to time rather than to replant with old varieties which had begun to wane in popular favour.

There is, however, the problem of contamination of clonal varieties by rogue plants, either of seedling or clonal origin, or by diseased plants. This contamination may materially reduce the yield from a plantation and give the impression of a senile change, or "running-out", in a variety. The solution must lie in the prevention of the propagation of rogue types by care in taking bud-wood or cuttings, and by vigilance in the nursery.

(11) Self-sterility occurs in many varieties of fruit crops. Even different varieties may not be sufficiently cross-fertile to ensure sufficient setting. Some edible fruits develop with a low percentage of ovules fertilised, and in these, high degrees of sterility can occur without affecting yield. In a seed crop, however, a high percentage of ovules must be fertilised, as seed is rarely produced without fertilisation. In such crops, therefore, precautions must be taken against sterility by planting mutually cross-fertile varieties together.

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REVIEWS.

The Use of Fertilizers in Tropical and Sub-Tropical Agriculture.

By A. Jacob and V. Coyle. *E. Benn Ltd.*, London. 1st Edition, 1931, pp. 272. Price 10s. 6*d*.

This book is intended to serve as a source of information to planters regarding the use of manures for cheapening crop production in extra-temperate regions by improving quality and by increasing yields per unit area of cultivated land. The subject matter is arranged in a manner generally adopted in such books. The following topics are first discussed; functions of fertiliser constituents in the plant; composition of tropical soils; classes of fertilisers, their application, and the methods of conducting manurial experiments on estates. The various crops are then considered in turn, and their different manurial requirements are briefly described. Many time-honoured statements are made regarding the special effects of the main manurial ingredients, and the usual attempt is made to construct nutrient balance-sheets for soils supporting various crops. The significance of factors other than nutrient supply in crop production is unfortunately not especially stressed. The chapter on tropical soils is very general. Perhaps too much hope is offered to planters who believe that the chemist can determine manurial requirements by analysing soil samples sent to him from areas which he can never inspect. Nevertheless it is correctly indicated that the final test lies in quantitative field experiments. In this latter connection, however, the chapter on manurial trials seems to overstress the value of extremely simple estate experiments, and insufficient consideration of the need for correct balance of nutrients is given. Manures act on the plant only through the soil, but soils react differently to manurial treatment. The discussions on experience gained in manuring different crops are necessarily very sketchy because of the limited size of the book. The reviewer is somewhat disappointed by the treatment of crops of which he has some personal experience. On the whole, the book can be recommended to the non-critical planter not particularly versed in soil science.

F. H.

* * *

West African Botany.

By F. R. Irving, *Oxford University Press*. pp. 204, 3*s*. 6*d*.

Textbooks of Elementary Botany with tropical examples are as yet very few in number and since this is the first to deal with West African plants it should be indispensable not only to African schools but to those of other tropical countries. The keynote throughout is simplicity and practicability and the book stands apart on account of the author's quiet simple logic and patient explanations.

An enormous amount of information is very skilfully presented since on reading there is never any feeling of cramming. Indeed the author is fortunate in having such a huge flora at hand to deal with for the almost unlimited examples quoted are practically all common plants.

The most pleasing part of the book is the attention paid to illustrations. Practically every example cited is sketched alongside. The sketches are simple and clear and serve well to emphasize the point. In one chapter there are forty illustrations for nine pages of reading, probably a record for any book of its kind.

F. J. P.

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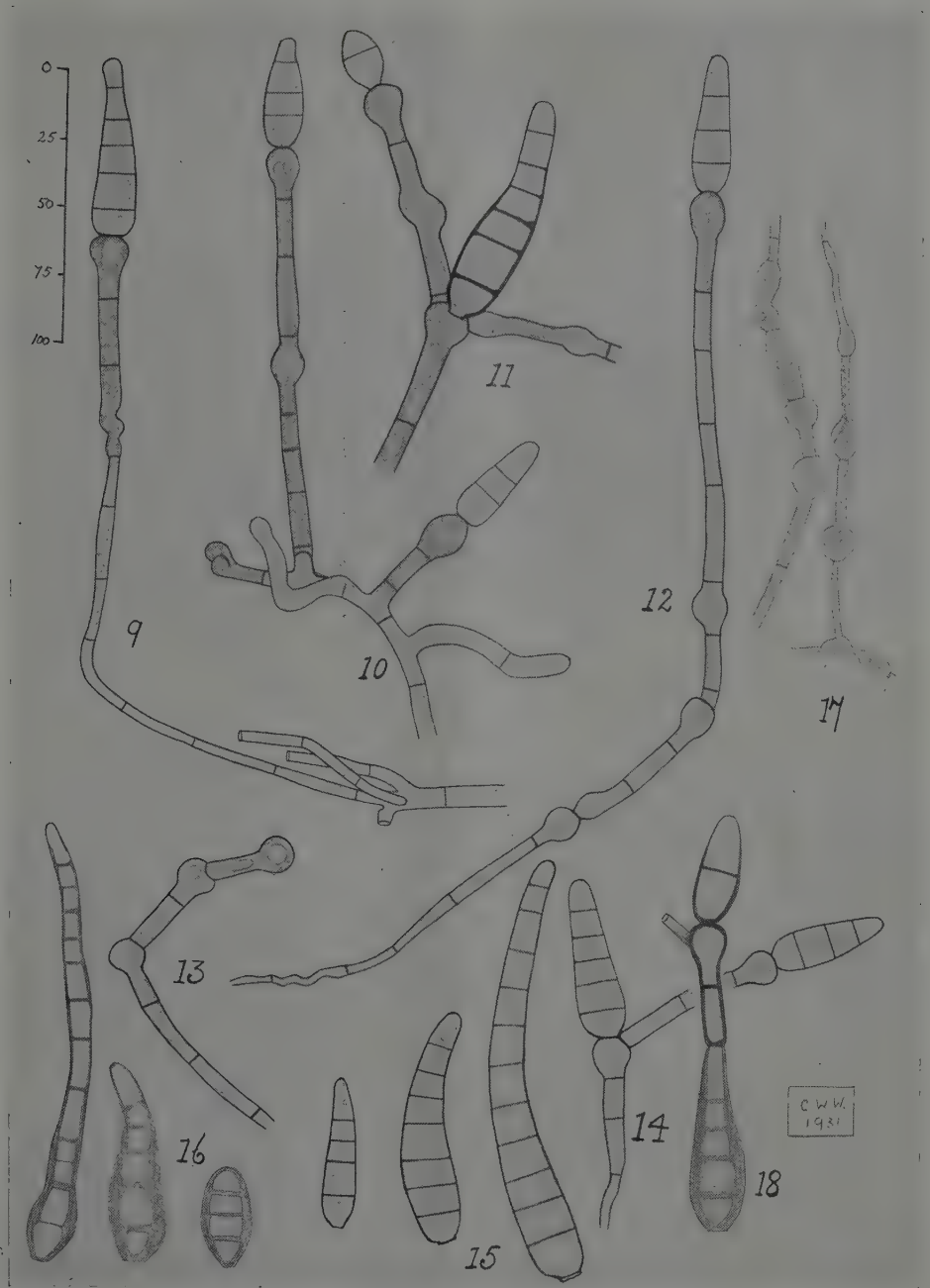
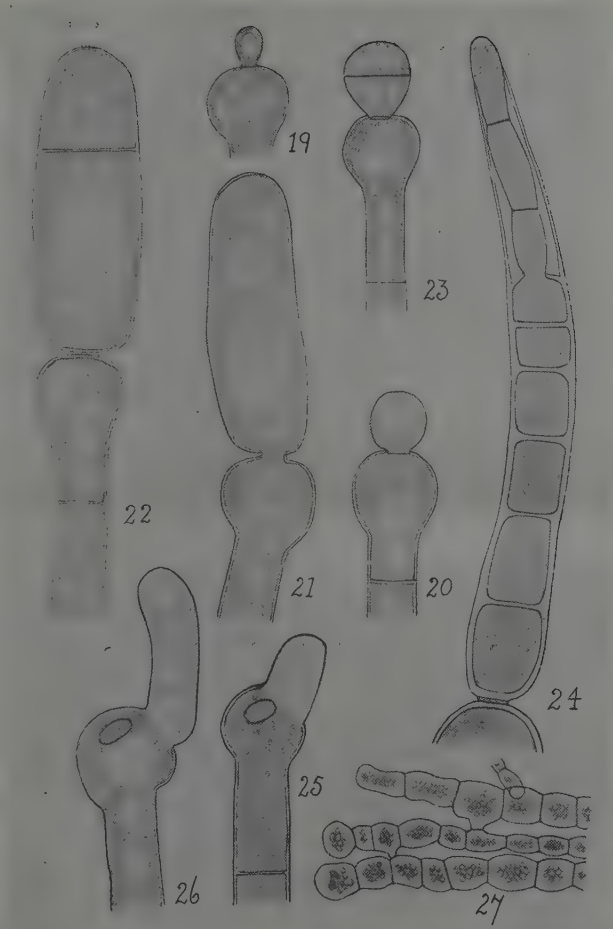
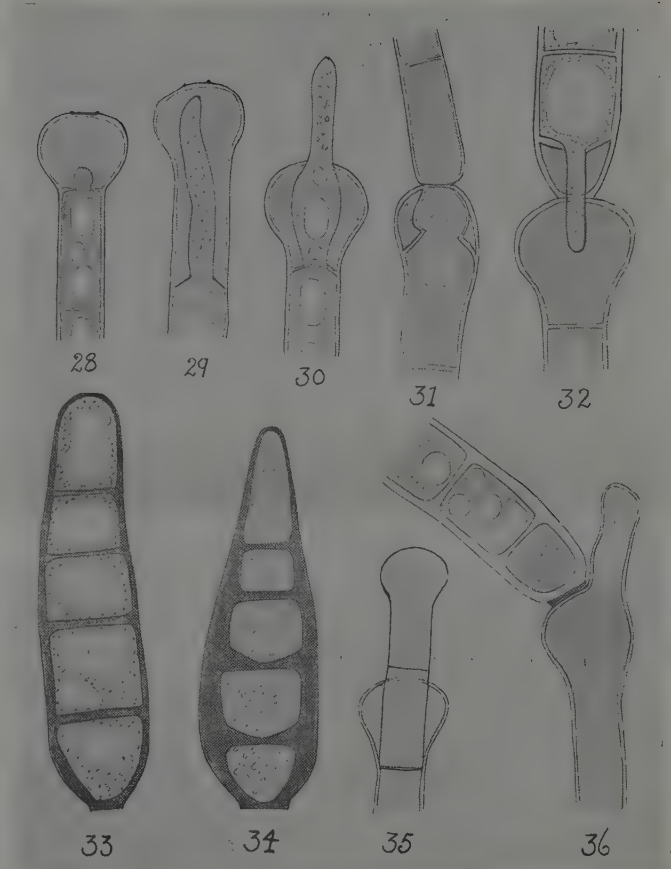
BANANA DISEASES.



FIGS. 9-18.—*Conidiophores and conidia of Helminthosporium torulosum* (Syd.) *comb. nov.* Ashby. *See text.* (×450.)



FIGS. 19-23.—*H. torulosum. Detailed studies of the formation of conidia.* (×1100)
FIG. 24.—*Abnormal development in conidium.* (×1100)
FIGS. 25-26.—*Early stages in the development of conidiophore braches.* (×1100.)
FIG. 27.—*Conjugation between cells of procumbent mycelium.* (×375.)



FIGS. 28-31.—*Renewed growth of conidiophores by the development of the penultimate cell. See text.*
FIG. 32.—*Conidiophore head penetrated by a hypha from a conidium which has germinated "in situ".*
FIGS. 33, 34.—*Mature conidia from different media.*
FIGS. 35, 36.—*Conidiophore branches.* (×1100.)

TROPICAL WORLD NOTES.

Nigeria.

According to the Colonial Report for 1930, the prices of all commodities exported from Nigeria, were very low throughout the year. The price agreement entered into between some of the biggest firms was also a factor which tended to depress the export trade, though fortunately, as has repeatedly occurred before, the agreement only lasted a few months. The after-effects of the riots in the Eastern Provinces also tended to depress the export trade in the early part of the year, but in spite of all the adverse influences, the quantities of agricultural produce exported during 1929-30 were generally as great as, or greater than, ever before. The figures given below will show the extent to which prices of several agricultural products have fallen during the last three years.

Although total cocoa exports have fallen there was an increase in the quantity produced. The quality of the product improved steadily as a result of the Produce Inspection Scheme, but the price was so low that there was a tendency for cocoa to be held up by producers and middlemen with consequent deterioration in quality. In spite of low prices for groundnuts, there was a considerable increase in production as a result of new planting areas having been opened up for export by the new branch railway. With regard to cotton there was a rapid extension in the production of the Improved Ishan Cotton. Nigeria was severely attacked by locusts during the year and a very active campaign of destruction of "hoppers" was necessary. In many places the amount of damage done by locusts to food crops was considerable, but fortunately these localities are separated by belts in which the damage was quite insignificant so that food prices were not forced to exorbitant levels, though in some districts they were high for the time of the year. There were many fresh invasions of locusts from the neighbouring territories during the last months of the year and serious infestations of frog-hoppers were expected in this year's rainy season.

Years.	Palm Kernels per ton.	Palm Oil per ton.	Cocoa per ton.	Groundnuts per ton.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928	15 8 0	24 4 0	48 6 10½	12 18 0
1929	13 8 0	23 13 0	35 11 7	11 0 0
1930	9 15 7	16 13 0	29 16 3½	8 18 0

Exports figures in tons for the same years are as follows:

1928	246,537	127,110	49,209	103,162
1929	251,368	131,786	55,246	145,376
1930	259,491	135,632	52,276	146,271

Fiji.

According to *Colonial Report* No. 1539 for 1930, abnormal weather conditions prevailed during most of the year and practically all crops suffered from lack of rain. Dry conditions were experienced throughout the Group from June to November causing a check to crop development with low yields. Coconuts, which had suffered severe damage from the storm of December, 1929, did not recover to the extent hoped for. The rice crop was a poor one, but cotton yields were good on most of the areas planted. A severe hurricane was experienced and bananas in the Group suffered badly. Most of the old plantings were destroyed and many of the new areas just coming into bearing received a severe setback resulting in considerable loss to growers. Native houses and food crops were seriously damaged and in many instances destroyed.

Ninety thousand nine hundred and seventy-nine tons of sugar were exported during the year. Fiji suffered from the unprecedently low prices ruling in the world's markets, but there was no reduction in the price paid by the Colonial Sugar Refining Company Limited to growers for their cane. Yields were affected by the drought. The excellent cultural methods practised by the farmers, including the conservation of soil moisture, to some extent discounted the adverse weather conditions. The production of cane by East Indian farmers has been well maintained and the growing of cane by Fijians has recently received an impetus. The crop produced by natives at all mill centres amounted to 7,476 tons of cane. Some 80 per cent. of the total sugar-cane produced in the Colony is now grown by small-holders, mainly Indian. Work has been continued by the field staff of the Colonial Sugar Refining Company Limited on the breeding of new cane varieties. Pests and diseases are under control and progress has been made in checking the damage caused by the cane borer, particularly in the Labasa district.

Increasing quantities of pineapples, pawpaws and kumalas were exported during the year. There appear to be excellent opportunities of developing trade with Vancouver in certain agricultural products of Fiji, particularly coconuts, maize, green ginger and peanuts.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Oil from Sandal Seed.

In addition to the well-known essential oil from the heart-wood, sandal yields a valuable fixed oil which is present in its seeds. The oil can either be extracted by a solvent or pressed out hot in a suitable press. It is highly viscous, thicker than castor oil. It contains in solution an unsaponifiable resin which has a very high iodine value. The oil itself has an iodine value of 130, and dries up in the course of 24 hours when exposed to air in thin films. On boiling, the oil gradually thickens and the reaction proceeds rapidly when the operation is carried out with manganese or lead oxide. Sulphur reacts violently with the oil at about 200°C., yielding a rubber-like mass. Colophony, copal, dammar, and ester gums can be dissolved in the oil to obtain oil varnishes suitable for wood and iron work. Further investigations on this oil are in progress in the biochemical laboratories of the Indian Institute of Science.—(*Ind. and Eng. Chem.*, News Edition, Vol. IX, No. 19, p. 301.)

* * *

Commercial Production of Laevulose.

Laevulose occupies the unique position of having had a striking demand developed far in advance of its commercial production. To mention one possible use, a remarkable laevulose tolerance is exhibited by diabetic patients.

At the Iowa State College a semi-commercial plant, capable of producing 50 lb. of laevulose per day has been in operation during the past year, using the Jerualem artichoke as the raw material, because of its many good features from an agricultural viewpoint. By drying the artichokes, many advantages are obtained, including the operation of the plant throughout the year.

A continuous-precipitation process has been developed, yielding very granular lime laevulate, which may be easily filtered and washed. The preparation of crystalline laevulose in good yields has been accomplished at ordinary temperatures without the use of refrigeration.—(*Ind. and Eng. Chem.*, Vol. XXIII, No. 11, 1931, p. 1202.)

* * *

Citrus By-Products Laboratory in Texas.

The Bureau of Chemistry and Soils, United States Department of Agriculture, is to open a new citrus laboratory on the land of the Texas State Experiment Station. Work on problems of citrus fruit utilization will begin as soon as the buildings are completed, and the first year's work will be largely on problems connected with the utilization of grapefruit. The laboratory will study the composition of different varieties of Texas grapefruit to learn what stage of maturity is most favourable for preservation, and will also investigate the utilization of waste from canneries and juice factories and the possibility of preparing grapefruit oil, pectin, naringin, and other by-products.—(*Ind. and Eng. Chem.*, News Ed., Vol. IX, No. 18, p. 285, 1931.)

Residual Effect of Fertilizers.

Greenhouse experiments, conducted for six years with wooded soils, show that fertilizers give the greatest benefits during the year in which they are applied. Residual effects may be produced from Phosphates, Potash, or organic fertilizers, but none from Nitrates. With wheat the residual effect of various fertilizer combinations was only slight the second year and nothing at all the third year. However, with clover much greater increases were noted the second year and an appreciable effect the third year. Clover turned under showed decided increases in the subsequent wheat crop: it gave three times the yields from the controls and again doubled the yields from the previously phosphated crops. Direct and residual effects of fertilizers were reflected in the composition of the crop. The percentage of Phosphorus in some of the clover was three times that of the controls. In field experiments with both wooded and black soils, normal fertilizer applications gave slight residual effects on cereals but significant yield increases the second year with legumes.—(F. A. Wyatt, *Sci. Agr.*, Vol. XI, 1931, p. 387.)

* * *

Production of Starch from Sweet Potatoes.

The sweet potato is primarily a starch producer, and the possibility of utilizing the excess crop as a source of commercial starch has been investigated at the Bureau of Chemistry and Soils, United States Department of Agriculture.

A procedure has been devised for manufacturing starch whereby objectionable colour can be largely eliminated from the starch, regardless of the colour of the potato flesh. The method involves utilization of sulphur dioxide in the water used in grinding the potatoes. This treatment apparently keeps the pigments carried by the starch in a reduced form until they are extracted later in the process by a dilute sodium hydroxide solution, which is thoroughly washed from the starch before it is dried. The other operations—namely, the grinding of the potatoes, the separation of the starch from the pulp, purification of the starch by settling, and drying of the starch—are essentially the same as for production of white-potato starch.—(*Ind. and Eng. Chem.*, Vol. XXIII, No. 11, 1931, p. 1205.)

* * *

Leguminous Bacteria and Plants.—Activity of leguminous bacteria and the utilization of fixed nitrogen from nodules of legumes by non-leguminous plants.

Nitrogen compounds formed in root nodules of legumes diffuse into the soil and are utilisable, either as such or after ammonification, by other non-leguminous crops. In a mixed crop of peas and oats the latter gained additional Nitrogen if the ratio of peas to oats was 1 : 1 or 1 : 2 but with a smaller ratio the growth of both plants declined. This effect varies with the pH of the soil. Similar results are obtained with other combinations of crops. (*Z. Pflanz. Dung.*, 1931, Vol. XXI, A, p. 57: *Brit. Chem. Abs. A.* Sept. 1931 p. 1101.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Production of Plastics from Sugar.

Some particulars have already been published in these columns* regarding new plastic materials which can be made, it is claimed, from "polymerized sugar". "Sakaloid" is the name which has been given to this sugar plastic. It (or a form of it) can be made from sucrose, dextrose, levulose, molasses, and even sugar-cane itself. Some further information is now given by the inventor Arthur S. Ford, which in view of this possible commercial utilization of sugar is of not a little interest. He writes as follows:—

"Sakaloid when first prepared, is a thick, highly viscous, elastic mass and this can be placed in solution for lacquers and varnishes, can be poured into moulds to set, can be die-cast, or can be processed further into elastic rubbery plates, sheets or rods, all of which take a brilliant polish and have all the appearance of the clearest quartz or glass.

"Rubba-Glas is the name given to this stage of the product and it is in effect a glass which can be cut, sliced or machined with ease. It is tough, elastic and can be bent or twisted like so much rubber. This stage is controllable and can be rendered permanent by variations in manufacture so that the product remains permanently flexible and resilient. Its clarity permits the widest latitude of colour, a drop of concentrated dye in the mix resulting in a perfectly distributed tint.

"The next stage of Sakaloid is the hardened form, and when this is carried through we have the final brilliantly clear, quartz-like product. This is an ideal lens and optical material with a refractive index approaching quartz, a transparency to ultra-violet and infra-red rays, and with it all a material that can be drawn, machined or drilled in any manner. It is from this end-material that the moulding powder is made and this powder when hot pressed flows and forms like plastics of the familiar type, but the moulded piece is as transparent and clear as glass. Once this has been done the material ceases to be thermoplastic, heat serving only to harden the material further.

"Sakaloid in all its forms is absolutely unburnable. It gives off no gases on exposure to flame. It does not melt; even will not support a flame but simply chars when the heat of the flame grows too intense. For X-ray and photographic films of all kinds, Sakaloid offers many practical advantages beside being unique in its use for moulded cases and boxes where complete visibility of the contents is desired. Sakaloid can be sheeted for protective package purposes in any degree of thinness or thickness without losing its perfect clarity and of course it can be applied to paper or textiles for a host of purposes. Sak-a-tex is the name given to this branch of manufacture and a wide use of this line is indicated. Sak-a-lac is the type of material designed for varnishes and lacquers. Sak-a-tine is the name for the material when extruded into filaments for spinning and weaving as an artificial silk."

Assuming this plastic made from "polymerized sugar" to be all that is claimed for it, and assuming further that it were to take the place of all the materials at present used in the moulding industry in Europe and America, this would not absorb any very great quantity of sugar from the world's markets. A rough estimate would not suggest more than 100,000 tons. But we have considerable faith in the future of the moulding industry, which, one may add, is one of the very few which has made some little progress during the depression. So far plastics have been used for the production of small articles, mostly possessing special insulating properties; but there seems little doubt that cheap plastics for the production of timber substitutes such as might be used in making furniture, for example, will be a development of the future. If it is true, as stated above, that a plastic can be made from molasses, this opens up the possibility of using that by-product (it may be with bagasse flour as filled, or in combination with the entire bagasse) for the production of boards or blocks locally on the plantation, employing a simple and inexpensive moulding plant.—(*Int. Sugar Jr.*, Vol. XXIII, No. 395.)

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Potentiometric determination of Reducing Sugars.

H. Tryller. Z. Spiritusind. (1929) *52*, 27-28.

[*Attention is drawn to the following abstract taken from Jour. Soc. Chem. Ind., which describes a potentiometric method for the determination of reducing sugar. This rapid method is in use in Government Laboratories in the West Indies and in laboratories at the College, and has been proved to yield accurate results. It is particularly useful for determinations on highly coloured solutions, such as molasses. Fuller details may, if desired, be obtained from this Department.*]

In the determination of reducing sugars by titration against Fehling's solution the end-point is ascertained electrically by the vanishing of P.D. between two thick copper wires (electrodes) one of which is immersed directly in the boiling reaction liquid and the other is enclosed in a tube containing a similar solution free from copper, closed at the bottom by a porous plug and also immersed in the reaction liquid. The free electrode and the tube containing the enclosed one pass through the stopper of the reaction flask, which also has an opening for admission of sugar solution from a burette and for escape of steam. The two electrodes are wired to a galvanometer. As the end-point of the reaction is approached the galvanometer deflection approaches zero and becomes extremely sensitive to slight changes of copper-content of the reaction liquid, so that the end-point can be easily ascertained to 0.1 cc. of sugar solution.—(*Journ. Soc. Chem. Ind.* (1929) *48*, p. 223B.)

* *Trop. Agriculture*, Vol. VIII, No. 12.

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
29th October ..	6 6	10 3
5th November ..	6 6	10 3
12th November ..	6 6	10 3
19th November ..	6 4½	10 1½
26th November ..	6 3¾	10 0
3rd December ..	6 7½	10 4½
10th December ..	6 9¾	10 6¾
10th Dec. (1930) ..	6 6	9 4½

There have been no developments in the sugar market which call for special comment, the record of business being somewhat uninteresting although steadiness has generally characterised the trend of values. According to *Messrs. Czarnikow Ltd.* the overwhelming victory of the National Government has created an atmosphere of optimism in commercial circles in the United Kingdom which should tend gradually to restore confidence abroad and lead to a more stable value of sterling. Licht's estimates which were expected to be higher have revealed that there will practically be no change in the European statistical position. The statistical position in Java which has been somewhat uncertain is expected to improve owing to a recent steady appreciation in the value of silver.

* * *

COCOA.—Despite the strong statistical position of cocoa the market continues at a low level and with present uncertainty in business, due to exchange fluctuations, there appears to be no immediate sign of improvement. The main Accra crop now being reaped will be short and estimates point to smaller figures now being realised for last crop. The price for this grade cocoa may now be quoted at 26*s.* 9*d. c.i.f.* and locally the market is around $8.00 a fanega (110 lb.).—*By courtesy of the Cocoa Planters' Association of Trinidad, Limited.*

* * *

COFFEE.—Prices for better coffees have been encouraging. Recent quotations per cwt. include Colombia 100*s.*; Kenya 62*s.* to 130*s.* with good business at 87*s.*; Costa Rica 104*s.* and 127*s.*; and Good Brazilian at 52*s.* 6*d.*

* * *

TEA.—According to the *Times Trade and Engineering Supplement* tea averages in the third week of November were Ceylon 17.73*d.*; Indian 11.40*d.*; Java 8.49*d.* There has been a slight fall in prices although sales have been larger.

RUBBER.—Quotations for Plantation Sheet have ranged as follows :

28th October	$2\frac{7}{8}$
4th November	$2\frac{3}{4}$
11th November	$2\frac{15}{16}$
18th November	3
25th November	$2\frac{15}{16}$
2nd December	$2\frac{15}{16}$
9th December	3
10th Dec. (1930)	$4\frac{3}{4}$

The market, since our last report, has only fluctuated slightly, the chief influences being the movements in sterling exchange, and rumours arising out of the possibility that the Dutch Government, owing to the serious financial conditions in the Dutch East Indies, might look more favourably upon any measures tending to alleviate this position. Revised estimates for 1931 by *Messrs. Symington and Wilson* place production at 780,000 tons and consumption at 650,000 tons. A trade revival in America apparently is more important from the rubber point of view than anything that may happen in the United Kingdom.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*	*Sea Island.*		
			Good.	*Extra fine.*	*Prices paid this Week.*
30th Oct.	4·99	7·35	—	—	—
6th Nov.	5·03	7·55	—	—	—
13th Nov.	5·06	7·60	—	—	—
20th Nov.	4·89	—	—	—	—
27th Nov.	4·90	—	—	—	—
4th Dec.	5·14	—	—	—	—
11th Dec.	5·21	—	—	—	—
10th Dec. (1930)	5·63	—	—	—	—

On the whole there has been little change in the cotton situation and although the Bureau reports a much increased crop estimate, this factor appears to have exercised little influence on the market.

* * *

BANANAS.—The market for Jamaicas has continued fair, prices being advanced since the date of last Summary to £17 5*s.* per ton delivered London, and £17 per ton delivered nearest railway station. The demand for Brazilians has been good, prices remaining unchanged at £15 15*s.* per ton delivered nearest railway station.—(*West India Committee Circular*, 12th November.)

* * *

LIME PRODUCTS.—*Lime Oil.*—In spite of supplies of Handpressed being available on the spot, buyers are holding off, while Distilled is neglected, values being nominally unchanged.

Lime Juice—Raw is neglected and sellers appear willing to entertain bids below recent values. Concentrated. The last quotation was £5 but no business has been reported recently.—(*West India Committee Circular* 12th November.)